ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 62. No. 3 — 220 Broadway, New York, July 15, 1909.

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The Locks of the Panama Canal.

As our readers will recall, the plan on which the Panama Canal is being constructed involves the creation of a great inland lake submerging the swamps of the lower Chagres Valley and covering nearly two-thirds of the width of the Isthmus. This lake will extend to within five miles of the Atlantic at the Gatun dam and its level will be carried all the way through the Culebra cut. The surface of this lake will be 85 ft. above the ocean and vessels entering the canal on the Atlantic side will be raised into the lake by a flight of three locks built in the hillside adjoining the Gatun dam. At the Pacific end of the Culebra cut, a single lock at Pedro Miguel will lower vessels to a small lake a mile in length extending to a flight of two locks at Miraflores. Descending these locks, the vessel will enter a section of a channel excavated to ocean level and extending to the Bay of Panama and through a dredged channel in that bay straight out to deep water in the Pacific.

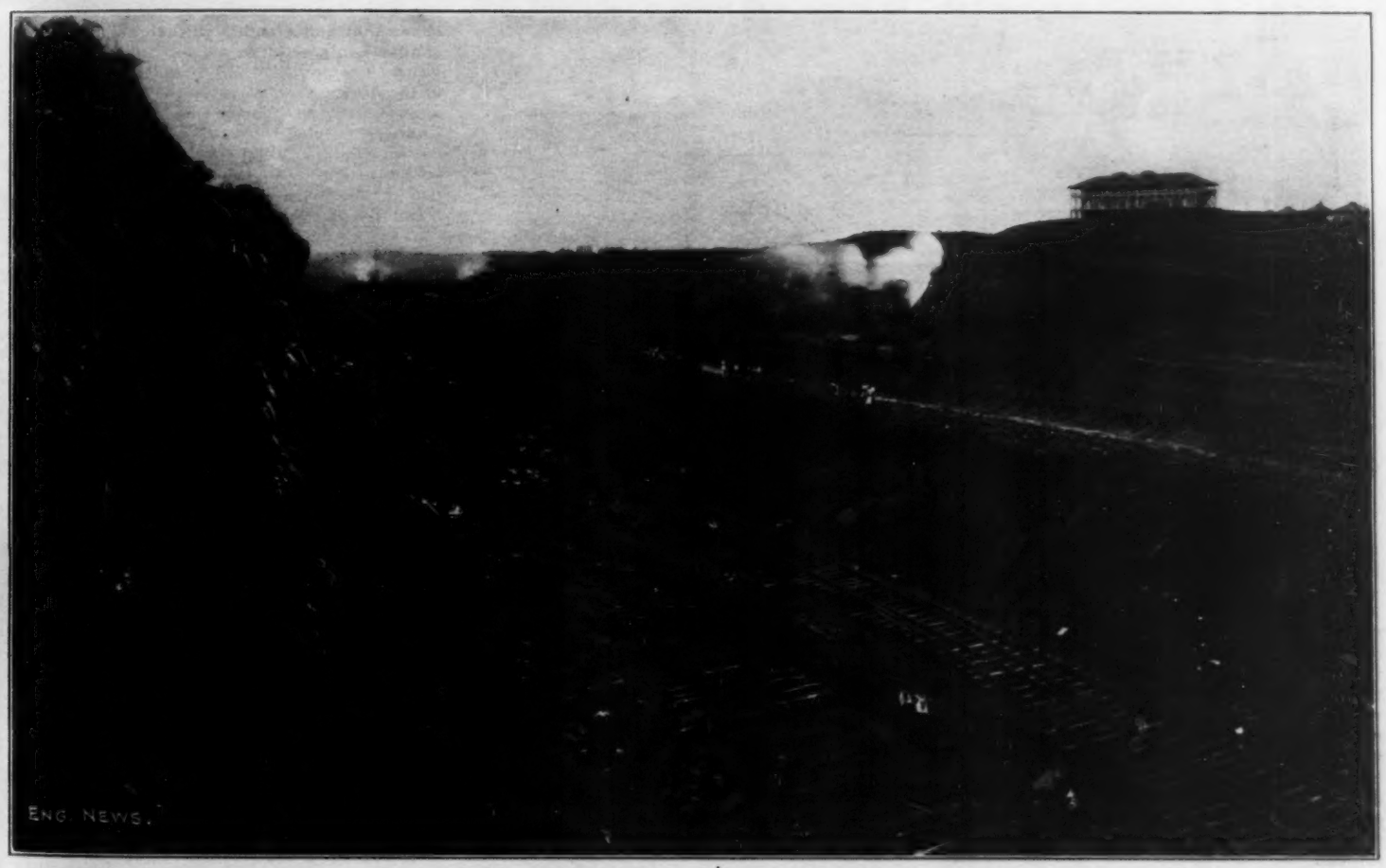
All the locks are to be in duplicate, so that any lock may be put out of service for repairs without interruption of traffic.

The Lock Dimensions.

The locks of the Panama Canal will be the largest canal locks ever constructed. Each lock is to be 1,000 ft. in clear length, 110 ft. in width and the average lift will be 28⅓ ft. It is not generally realized even by engineers, and much less by the general public, how enormous these locks are in comparison with the size of the vessels that will probably use the canal for many years to come. It seems worth while, therefore, to rehearse a little of the history of these locks and explain how they came to be made of such enormous size.

Going back to the first report on the Nicaragua Canal project made by the Ludlow-Noble-Endicott Commission of 1895, it is of interest to note that the dimensions of the locks proposed by that Commission for the Nicaragua route were 650 ft. length, 80 ft. width and 28 ft. lift. In the original plans of the Menocal company, locks with a lift of 45 ft. were proposed; but the Ludlow Commission advised a lower lift, particularly in view of the fact that some of the locks had to be founded on clay.

The Walker Commission of 1901, by whose recommendation the Panama route was adopted, planned locks 740 ft. long and 84 ft. broad. The reasoning by which these dimensions were arrived at is so cogent that it is worth reprinting in full:



EXCAVATION AT THE GATUN LOCK SITE, JUNE, 1908.

> In fixing the width of locks and prism it is not necessary to take into account the fast passenger ships of the North Atlantic routes. Such a trade is not likely to develop through the Isthmus. Limiting the inquiry to freight or combined freight and passenger ships like those mentioned, it will be noted that the maximum beam of 73 to 76 ft. is found in very few ships; excepting these, the greatest is 63 to 65 ft., which is found in quite a numerous class. If the canal were intended for commercial uses only, it might be questioned whether dimensions should be fixed for the extreme beam of 75 ft. or more, with the added cost of construction and minor disadvantages, but the imperative requirement that the canal shall afford a passage for the largest warships

makes it necessary to provide for a beam considerably greater. The broadest ships building for the United States Navy are those of the "Virginia" class which have a beam of 76 ft. and 2½ ins. The broadest battleship afloat is the Italian ship "Regina Margherita," recently launched, which has a beam of 78.2 ft. While the increase in beam of warships has for some years been less rapid than that of commercial ships, it is unmistakable. For convenience in operating the locks the width should be 2 or 3 ft. greater than the beam of the ship. The width is therefore fixed at 84 ft. with a view to provide for some further increase in beam of ships.

The largest ships of war are shorter than commercial ships of like beam, and a clear length of lock chamber of 600 ft. would be sufficient for any warship now afloat or building. In order to make the canal practicable for the largest existing commercial ships, and also to provide for a considerable increase in size, the only additional expense to be incurred in the building of the canal, after providing for warship requirements, is to increase the length of the locks. This added cost is so small in comparison with the advantage gained that it is unquestionably judicious to incur it, and the length is therefore fixed at 740 ft. in the clear.

We believe this reasoning is as sound to-day as it was eight years ago. Nevertheless the situation has been somewhat altered by the action of Congress when it selected the Panama Canal route.

The Spooner law, passed by Congress in June, 1902, authorizing construction of the canal, provided that it should "be of sufficient capacity and depth as shall afford convenient passage for vessels of the largest tonnage and greatest draft

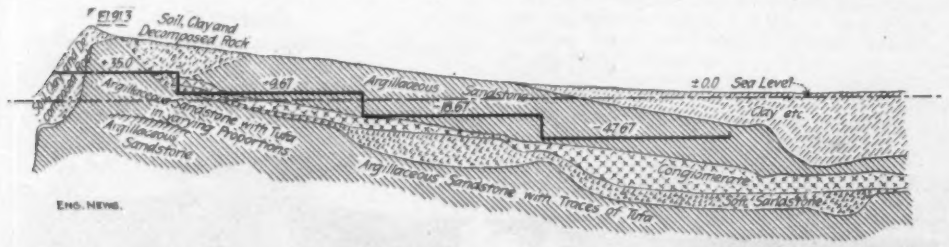


FIG. 2. PROFILE ALONG SITE OF CENTER WALL OF GATUN LOCKS SHOWING MATERIAL UNDERLYING LOCK FOUNDATIONS.

now in use, and such as may reasonably be anticipated."

This language made it necessary to take into consideration in fixing lock dimensions the huge transatlantic passenger vessels which have been produced during the past half dozen years, notwithstanding the fact that they are not duplicated, and are little likely to be duplicated, on any other ocean trade route in the world.

We emphasize this matter for it is one on which the public is widely astray. So much is said in the public prints about the great new steamships of record-breaking size or speed, that it is easy for one to conclude that the merchant marine of the world is shortly to be reconstructed on a similar gigantic scale. The fact is, however, that the average size of ocean carriers, although it has steadily increased, lags very far behind the size of the floating leviathans which are only made possible and profitable by the enormous traffic between the United States and Europe. The world's ocean traffic is still carried and is likely long to be carried in vessels of moderate size. One of the best demonstrations of this is the average size of the vessels passing through the Suez Canal. The average tonnage of the vessels passing through the Suez Canal in 1908 was 3,592 tons.

By way of illustration of a typical first-class vessel of the present day intended for other than the transatlantic trade we may take five new steamships of the Orient Steam Navigation Co. which are just being constructed to ply between Adelaide, Australia, and Europe, and by the terms of a mail contract with the British Government are to reduce the time from Brindusi to Adelaide, to 638 hours. The vessels are designed to carry about 5,000 tons of cargo and nearly 800 passengers. Their principal dimensions are as follows: Length, 553 ft.; beam, 63 ft. 6 ins.; gross tonnage, 12,036 tons; draft, 24 ft., 3 ins.; horsepower, 12,000; average sea speed, 16 to 17 knots.

The language of the Spooner act, however, made it necessary to consider the size of the largest vessels built or likely to be built whether for the transatlantic trade or elsewhere.* The engineers on the International Board of 1906 who framed the plan now being carried out at Panama therefore collected statistics of the large merchant and naval vessels of the world. These statistics we summarize as follows:

BEAM OF LARGE OCEAN STEAMERS.

Beam.	Existing merchant vessels (1905).	Warships in use or projected.	Total.
40 to 50 ft.	4,094	340	4,434
50 to 60 ft.	809	193	1,002
60 to 70 ft.	79	167	246
70 to 80 ft.	9	166	175
80 to 85 ft.	...	8	8

From a study of the statistics, the engineers above referred to, in 1906, adopted a width of 95 ft. for the Panama locks and a length of 900 ft. They pointed out that these dimensions would accommodate ships nearly double the tonnage of the "Dakota" and "Minnesota," the huge vessels built in 1904 by James J. Hill for the transpacific trade, which vessels the Board said "are so much larger than any other on the Pacific that they must be considered experimental."

The lapse of years appears to fully justify this statement on the Board's report. As our readers know, the "Dakota" was wrecked not long after she began running and there has been no move made to replace her, or to add to the number of such huge vessels in the Pacific trade.

The reasons are almost apparent on their face. The depth of harbors, the port facilities and the volume and character of ocean-borne traffic on the Pacific does not make such huge vessels profitable.

We believe that the dimensions recommended by the Board of 1906 for the locks were ample; and that for fully half a century to come, the chief criticism passed upon the Panama Canal after its completion will be that it has been built of far larger dimensions than the size of vessels or the volume of traffic through it warranted.

But the criticism which those responsible for the conduct of the great enterprise have had to meet has been all from the opposite standpoint. Those who labored three years ago to persuade Congress to attempt a sea-level canal at Panama were unsuccessful. They did succeed, however, in causing the length of the locks to be increased to 1,000 ft. and the width to 100 ft. Later the width was further increased to 110 ft. at the instance of the Naval Board, which foresaw, probably, the coming craze for constructing "Dreadnoughts" by the nations of the world.

The present width, however, greatly discounts future increase in the beam of battleships. The necessities of speed prevent any great increase of beam in such vessels without corresponding increase in length and also displacement. War vessels, requiring heavy armor plating, cannot add to length as the ocean greyhounds have done. Increase in beam of battleships, therefore, is only by inches, and a battleship as large as the Panama locks would pass would be such a monstrosity that even the most rabid naval enthusiast could hardly urge it as a practicable weapon for national defense.

Long before such a battleship appears above the horizon a worldwide reaction is likely to occur against the intolerable burdens created by the national competition in naval armaments.

*The dimensions of the "Olympic" and "Titanic," which are being constructed for the White Star line to eclipse in size the Cunard Company's huge record-breakers, the "Lusitania" and the "Mauretania," are to be 860 ft. in length and 92-ft. beam.

The Lock Foundations.

All the locks of the Panama Canal will be founded on rock. This simple statement ought to be sufficient, one would suppose, to satisfy any reasonable person as to the safety and security of these structures; but the torrent of criticism to which the newspapers have given such wide publicity has included such wholesale denunciation of the lock foundations that some further word may be advisable.

In the first place—to make the record complete—it may be recalled that the lock foundations at Gatun were first criticised by the sea-level canal advocates on the ground that they were not long enough to permit of three 1,000-ft. locks being constructed. It should be understood that the locks are located in the hill which adjoins the Gatun dam site, and it was claimed that the hill was not broad enough to permit of building three 1,000-ft. locks, and further that this was the reason why the engineers who recommended the lock plan had adopted 900 ft. instead of 1,000 ft. as the length of the locks.

This criticism was promptly and authoritatively met by Mr. John F. Stevens, who was then Chief Engineer; yet the same old criticism has been brought forward by the newspaper critics within the past few months.

A glance at the accompanying profile, Fig. 2, shows that ample and more than ample length is available in the Gatun hill for the three 1,000-ft. locks. The profile, which is taken along the site of the center wall between the lock flights, shows also the material underlying the lock site. It ought to be clear by this profile that the locks are underlaid by solid rock. In fact there is no reason to expect anything else, since the rock is not a limestone formation in which caverns might possibly exist.

If the Gatun hill were located in the United States and it were proposed to place a canal lock or a 20-story building or a dam or any other engineering structure upon it, there would never be a syllable of questioning as to the sufficiency of the foundation material to carry the load upon it. But at Panama it is in order to conjure up all sorts of bogies; and the records and reports regarding the lock site at Gatun have apparently been examined with a microscope to twist some evidence out of some unguarded statement which could be used to arouse public uneasiness over the Gatun locks.

Now regarding the rock at Gatun it seems sufficient to say that it is a rather soft stone; but amply hard and with ample supporting power to bear many times the load that will be placed on it by the building of the locks. In fact, as may be seen on the profile, Fig. 2, much of this rock at Gatun at the level where the concrete of the locks will rest has been carrying for untold geologic ages a load as great as or greater than the locks will impose upon it. This same rock formation, extending all through this region is doubtless at the base of the hills and the mountains a thousand feet and more in height.

It will be evident, too, that a lock is really one of the safest structures, so far as foundations are concerned, since it has a base of such enormous area. The piers and columns of a building may impose a concentrated load over a small area, but when that area is supported by the adjacent rock around it, it is difficult to place any limits to the safe load that may be applied. The case is entirely different from the case of an isolated cube of rock crushed in a testing machine. There the cube is deprived of support at its sides and it fails under comparatively small load.

If further evidence is needed to satisfy any of those who may have been worried by the published criticisms of the Gatun locks, we would call attention to the similarity in construction between a dry dock and a canal lock. There are numerous dry docks quite comparable in size to the Panama locks; and almost without exception the dry docks of the world are founded on soft material. A large proportion indeed rest on

piles. When we compare the swamps and quagmires in which most of the world's dry docks are built with the rock at Gatun, it does not look as if one need spend much time worrying over the lock foundations.

But it is said that the rock at Gatun is water-bearing. Various fearful images have been conjured up because of the water that occurs in the rock of Gatun Hill. The late Senator Morgan, when one astute expert had been depicting the dangers which water in the rock indicated, inquired if springs did not flow from mountains and hills and yet the mountains stood; and the expert had to admit that the mountains stood.

If it were necessary to raise doubts of the stability of rock foundation because of its water-bearing character, then the owners of various high buildings in New York with artesian wells in the basement would be on the anxious seat.

The real reason why water in the rock foundations has some importance is because of the possibility of a hydrostatic upward pressure on the base of the lock floor which might possibly raise a section of it when the lock was empty. It is easy to guard against this, however, by inserting drains to relieve the pressure; and the indications are that the amount of water in the rock and the head upon it is far too small to counteract the great weight of the lock floor in any event.

Where there is any chance of such hydrostatic pressure occurring, the lock floor is to be anchored to the rock by old French rails, of which an abundance are available on the Isthmus.

Some idea of the character of the rock at Gatun may be gleaned from the photograph of the lock-pit excavation there, shown on p. 61. The prevailing rock at Gatun is what was formerly called "indurated clay," and is now termed argillaceous sandstone. Much of this material as found in the Culebra cut weathers and crumbles when exposed to the air. The rock at Gatun, however, both that in the spillway hill and at the lock site, is much more durable and stands in vertical faces with little weathering.

At Pedro Miguel the rock crumbles on exposure to the air but remains hard and firm as long as it is under water. In excavating for the locks at Pedro Miguel, therefore, the excavation has been stopped 4 or 5 ft. above the desired final grade. This material will not be removed until the work of concreting begins. Then it will be excavated close in advance of the concreting work so that the concrete will be laid on a rock surface.

It may be said here that this rock as it weathers is altered to a very slippery clay or fine greasy sand. If masonry dams were to be founded on this material, care would have to be exercised lest the dams slide on their base by reason of the small coefficient of friction on the rock surface.

The lock walls, however, while similar in cross-section and in the stresses carried to masonry dams, are held in position at their base by the concrete floors of the lock chambers, so that no sliding is possible, even though the friction on the base were reduced to zero.

Progress of Lock Excavation.

At the Gatun lock site the excavation in the upper lock chamber was expected to be completed by July 1. In the middle lock chamber about 10 ft. in depth remains to be excavated and in the lower chamber about a million cubic yards remain to be taken out. At the Pedro Miguel lock site considerable excavation was done by the French, who had plans for a lock at this point, but the present plans require about 1,200,000 cu. yds. additional to be taken out. All but about 200,000 yds. of this had been taken out by March last, and three steam shovels were then at work removing the remaining material.

At Miraflores, excavation for the upper lock is also far advanced and work on the installation of the concrete laying plant began last February. The suction cutter dredge "Sandpiper" has been at work for some months excavating soft material from the lower lock pit.

FIG. 3. EXCAVATION AT THE PEDRO MIGUEL LOCK SITE, JUNE, 1908.

It may here be noted that the total amount of excavation for the Gatun locks* will aggregate 5,139,304 cu. yds., of which nearly 3,000,000 cu. yds. were rock and 1,150,000 cu. yds. were material to be removed by dredging. About an equal amount of excavation is required for the locks at Pedro Miguel and Miraflores.

The Lock Structures.

The main structure of the Panama Canal locks will consist typically of a central dividing wall between the lock chambers and walls on each side, abutting against the solid rock of the lock pit excavation. The thicknesses of these walls are, in general, for the center walls 60 ft. and for the side walls 50 ft. The backs of the walls are stepped off to receive a back-fill, as in ordinary retaining-wall construction.

The material of the walls in all cases will be monolithic concrete. It would be desirable to bed large stones in the concrete—not for strength, for that is ample, anyway, for any stresses that can come upon the lock walls; but to economize in the use of cement. This theoretical saving by the use of large stones, however, would be probably more than counterbalanced by the delay that would be occasioned due to the different handling such material would require from the ordinary mass concrete. It is probable, therefore, that concrete alone will be used for the walls. The huge size of the lock walls will permit the use of a comparatively large aggregate for the concrete.

As stated above, the stresses are not so great but that ordinary concrete will readily sustain them. In a few cases where complicated sections occur, reinforcement will be placed, and parts of the lock floors where there is chance of hydrostatic pressure underneath will be anchored down with old steel rails. A very large tonnage of old rails, left over from the De Lesseps work, is available on the Isthmus. Curiously enough, while most iron and steel on the Isthmus rusts very rapidly, some of these old rails, after nearly a quarter of a century of exposure, show very little corrosion.

The Isthmian climate is an especially favorable one for concrete construction by reason of the very small variations in temperature. Concrete work laid in the northern United States, for example, may be subjected to a temperature of — 25° F. in February and as high as 110° under a July sun; on the Isthmus the temperature varies very little either way from 80°, summer or winter. While the sun is of course intensely hot, the frequent rains and large amount of moisture in the air tend to prevent articles exposed to the sun from reaching any such high temperature as is common in the dry Southwest. As is well known, temperature cracks in concrete work are due to the contraction in cold weather. So far as any temperature stresses at all occur in the concrete structures on the Isthmus, they will be due to the compression experienced when the concrete is exposed to the sun, raising the material to a higher temperature than that at which it set.

The accompanying cut (Fig. 4) shows a general plan, longitudinal section and cross-section of the upper locks of the Gatun flight. The description of this lock chamber applies, with small modifications, to the other locks on the canal.

In locating the levels of the miter sills and copings of the upper locks, the level of Gatun Lake had to be considered. The normal level adopted for the lake is 85 ft. above sea-level, which gives a depth of water of 45 ft. through the Culebra cut. It is planned during the latter part of the dry season to allow the level of the lake to rise, through control of the regulating works on the Gatun Dam spillway, until its level is at +87. The water thus stored will then be used for lockage purposes during that part of the dry season when the inflow into the lake is less than the amount required for operating the canal. The level of the coping of the upper locks has been fixed at 5 ft. above the high lake level, or +92. This may seem a needlessly high freeboard, but there is a possibility that the water may be raised a foot or two above the normal level at times. For example, a strong

*According to official estimates made in December, 1908.

southerly wind blowing down toward the head of the Gatun flight of locks may raise the water in the lake somewhat above the normal level, and there may be some wave action, also, to raise water against the head of the lock. On the other hand, there is very little probability that the full depth of the canal will be required for vessels for several years, at least, after it is opened. Even the greatest vessels afloat draw only 37 to 38 ft., and few vessels are likely to pass through the canal drawing over 27 to 29 ft. It is very likely, therefore, that for some years Gatun Lake may be kept considerably below the contemplated normal level of +85. A vessel drawing even as much as 30 ft. could pass through the Culebra cut with 3 ft. of water beneath its keel when the lake level was only 73 ft. above the ocean. In designing the locks, therefore, it has been kept in mind that navigation should be feasible with the lake as high as +87 and as low, say as +73.

The locks are designed to admit the passage of a vessel 1,000 ft. long. The clear length from the hollow quoins of the upper gates to the guard chain stretched in front of the lower lock gates is 1,000 ft. In each lock chamber, however, intermediate gates are placed, which, if used, will divide the chamber into two locks, respectively 400 ft. and 600 ft. in length. The gates controlling the culverts are so arranged that a vessel can be passed through a lock 400, 600 or 1,000 ft. long, according to its dimensions.

After much study of the various types of canal lock-gates which have been used, it was finally decided to adopt the ordinary miter gates. In a later issue we shall describe these gates in more detail. We turn now to the means for filling and emptying the lock chambers, on which a large amount of study has been expended. As seen by the plan and sections, a large culvert or tunnel runs through each side wall and the center wall for their whole length. Each of these tunnels has a cross-section 254 sq. ft. in area. Where of circular form these tunnels are 18 ft. in diameter. The tunnel in the central wall is horseshoe-shaped, with an arch 18 ft. across and a height of about 17 ft. It will be seen that each of these water passages is as large as a large railway tunnel. The entrance of the water from the lock into this tunnel is controlled by guard gates at the head of the lock walls, and the distribution into the several lock chambers is controlled by vertical Stoney gates moving on trains of rollers. At the point where these gates occur, the culvert or tunnel is divided into two parts by an intermediate pier. The control is thus effected through two gates, each of which closes or opens one half of the culvert.

From these tunnels in the lock walls, smaller lateral tunnels 6 ft. 6 ins. in diameter lead down and outward underneath the lock floor. From the roof of these lateral tunnels there are openings upward into the lock at intervals of 18 ft. These openings are about 3½ ft. in diameter and their aggregate area of cross-section is much larger than the cross-section of the lateral tunnel itself. Thus the water which passes the main gate controlling the flow into the tunnel at high velocity, is much reduced in velocity as it passes into the lateral tunnels; and its final entry into the lock occurs at comparatively low velocity.

The junction of each lateral culvert with the main culvert is controlled by a very simple form of cylindrical gate, which is operated from the top of the lock wall. By adjusting these gates, any desired distribution of the flow along the length of the lock can be made, so as to secure even filling and avoid longitudinal surging of the water in the lock chamber.

It will be noticed that the central culvert can be used for filling and emptying the lock chambers on either side of it. It may be thought that this might cause some interference, as it might be desired to use the middle culvert for filling or emptying two locks at one time. It must be remembered, however, that only when high speed in lockage becomes a matter of importance will it be really necessary to use the middle culvert.

In designing the intakes of the culverts at the upper end, as well as the junction of the main culverts and the laterals and the discharges from the lateral culverts into the lock chamber, great pains have been taken to facilitate the movement of the water and eliminate contractions. It is expected, therefore, that a coefficient of flow better than has been obtained in locks designed without these precautions may well be expected.

In the original estimates made by the Commission, the coefficients of flow which were assumed by the Deep Waterways Board in making its investigations were adopted. These coefficients were 0.75 for the upper lock and 0.66 for intermediate locks. Using these values, the side-wall culvert alone would fill the upper 400-ft. lock in 8 minutes and 53 seconds; or it would fill the 600-ft. lock in 11 minutes and 52 seconds, and the 1,000-ft. lock in 15 minutes and 37 seconds. These rates of filling for the 400-ft. and 600-ft. locks are probably at least as short as would be permissible in any event. Thus, it is probable that the side-culvert area alone will be sufficient to operate the two smaller locks. It is therefore proposed that when traffic in the locks becomes dense, the central culvert will be reserved for use in handling the 1,000-ft. lockages, while the side culverts will be used for the 400 and 600-ft. lockages. In this way there will

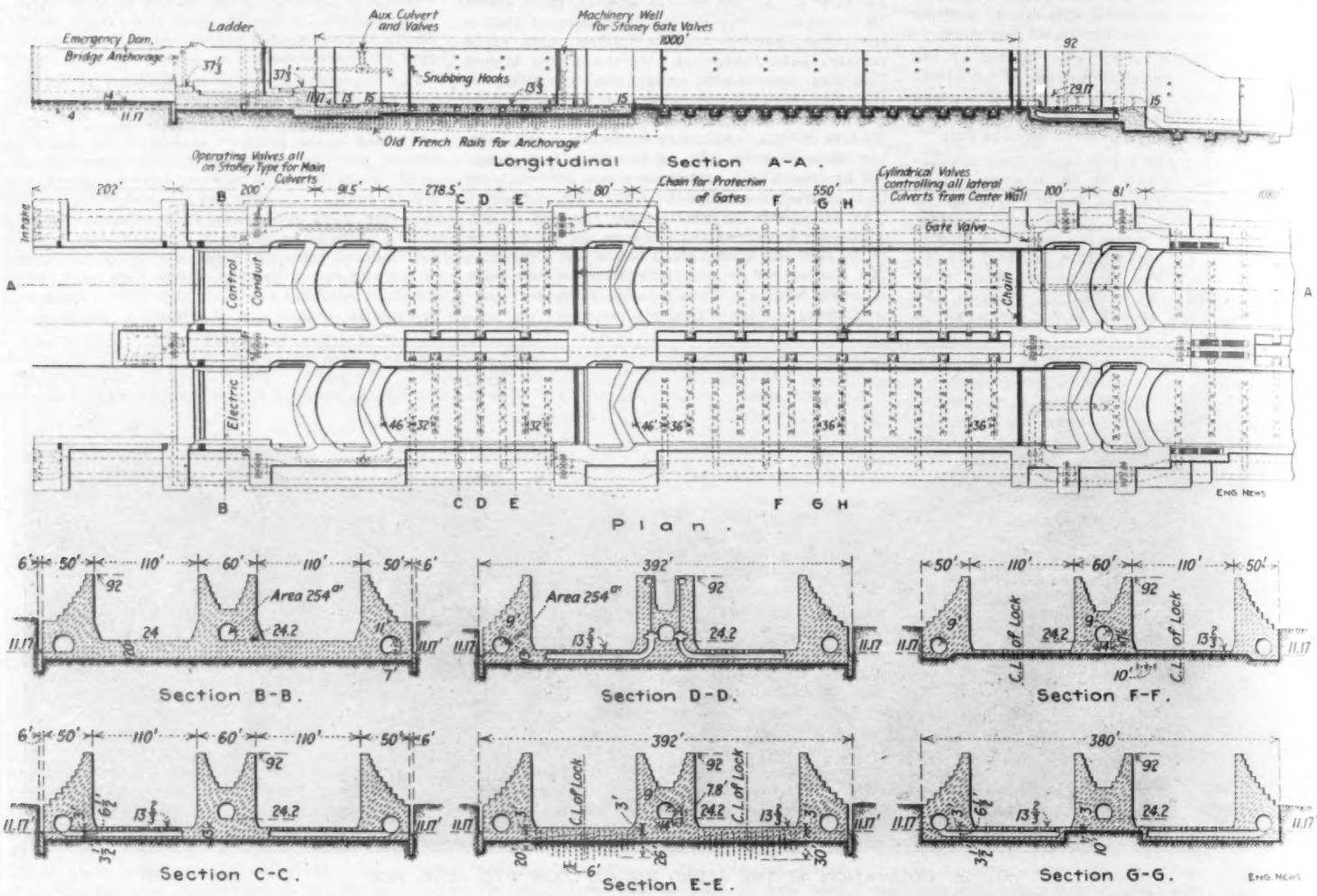


FIG. 4. GENERAL PLAN AND SECTIONS OF UPPER LOCKS OF GATUN FLIGHT.

be little possibility of interference or of the middle culvert being needed for one lock when it is in use for the lock chamber on the other side.

Besides the plan adopted, of a single culvert in the central wall, plans were studied in which two culverts were placed in the central wall. In order to make room for these two culverts, however, the center wall would have had to have its thickness increased to 80 ft., and even then the stresses would have been somewhat excessive under certain conditions. The additional cost of this arrangement would have amounted to $1,125,000 for the Gatun lock flight alone. The advantage of this arrangement was thought to be too small and remote to justify its adoption, and the single culvert in the central wall was therefore decided upon.

In the original plans for the locks, it was proposed to use, above the lower miter gates of each of the upper locks, a rolling gate which was intended as a guard gate to protect the main gates from accidental collision by vessels. This rolling gate was to move in and out of a recess in the lock wall, and plans in quite full detail were prepared for its construction. It was found, however, that this rolling gate was very much more expensive to construct than the miter gates, and in the spring of the present year it was finally decided to dispense with it and to use instead a double pair of miter gates, the upper pair acting as a guard for the lower pair. In addition, there is to be placed in front of each main gate a heavy cable chain which will be drawn up when the gate is closed, and when the gate is opened will be lowered and rest in a recess in the lock floor. This cable guard is not wholly new, but has been adopted in some of the recent large dry-docks built in England as a guard in front of the lock-gate.

In designing the lock walls, the side walls of the upper lock at Gatun have been computed on the assumption that they have to resist pressure of dry earth from +92 to +86, and water-soaked back-fill below that level. The maximum stress in these side walls occurs at the level of the lock floor and amounts to 20,300 lbs. per sq. ft. in compression. Below the level of the floor this stress is decreased by the reinforcing effect of the floor. Assuming the floor of the lock chamber to be 13 ft. thick, and that the base of the wall spreads out 60° with the horizontal from the toe, the maximum pressure on the bed of the foundation will not exceed 18,100 lbs. per sq. ft. This pressure will only occur when the lock is pumped dry for examination. In the middle wall, maximum stresses occur when the lock chamber on one side is full and the other is pumped dry. At this time the maximum stresses in the middle wall at the culvert level are 27,600 lbs. per sq. ft. in compression and 1,900 lbs. per sq. ft. in tension. The wall is reinforced with embedded steel rails to resist this tension. These maximum stresses occur only in the thinnest portion of the wall, between the recesses for the miter gates. In the main body of the wall the compression is much lower, and no tension occurs. The pressure on the bed of the foundation under the center wall at the gate recess, with a 13-ft. thick floor, will not exceed 16,000 lbs. per sq. ft. If any hydrostatic water pressure exists under the walls and floors, due to water confined in the rock, the pressures will be less than those given above, depending upon the head.

NEW RULES FOR TRANSPORTATION OF INFLAMmable articles and acids went into effect July 1 on all lines included in the American Railway Association, nearly 250,000 miles in extent. These rules are additional to the rules promulgated by the Interstate Commerce Commission on April 18 for the transportation of explosives. All these rules have been formulated under the direction of Col. B. W. Dunn, U. S. A., Chief Inspector of the Bureau for the Safe Transportation of Explosives of the American Railway Association. The magnitude of the operations with which this Bureau deals may be illustrated by the statement that there are in the United States more than 150 manufactories producing explosives, the output of which is 500,000,000 lbs. per annum. In the year 1906, a single railway company transported over 91,000,000 lbs. of explosives, and used over 19,000 cars in the work.

Annual Meeting of the American Society for Testing Materials.

(*Concluded from page 59 of our last issue.*)

Soundness in Steel.

Much time was occupied with various subjects revolving about the matter of soundness in steel, and five or six papers were read dealing with such subjects. They portray clearly the fact that very active investigative work on soundness is now in progress, and permit the hope that practical improvements may soon result in the direction of reducing the chance for unsoundness in rolled steel.

COMPARISONS OF INGOT AND ROLLED STEEL.—Studies have been in progress at Watertown Arsenal for over a year on the question of what relation exists between the structure and defects of rolled metal and the structure and defects of the ingot from which it was made. A sketch of some results obtained up to the present was given by Mr. J. E. Howard in "Notes on Tests of Ingots and Derivative Shapes in Progress at Watertown Arsenal." Numerous etched sections and microphotographs illustrated the observations made. The general conclusion is given that

> the markings commonly brought out on the cross-sections of steel rails by etching are believed to be those which have their origin in the ingot, modified by subsequent treatment, and that the state of the metal in the ingot, as regards presence of slag and zones differing in structure at this stage, carries through the several passes to the finished rail.

This points to the need for laboring toward improvement of the ingot, which is receiving increasing recognition; certain fundamental troubles, chiefly inclusions of slag, but probably also segregation zones and blowhole lines, if existent in the ingot, remain in the finished shape and constitute lines or planes of weakness.

SLAG INCLUSIONS.—The first factor was discussed by Prof. Henry Fay and Mr. R. W. G. Wint (Mass. Inst. of Tech., Boston, Mass.), in a paper entitled "Further Investigations of Broken Steel Rails," which was illustrated by excellent microphotographs. The authors depart from their previous special condemnation of manganese sulphide by asserting now that other forms of slag (for example silicate of manganese) also give rise to trouble in steel. They show by their photographs that slag inclusions are present in large number and unfavorable form in steel which breaks unnaturally. The authors make the point that slag is vastly more frequent a defect of steel rails than bad structure, and urge as a step toward improvement the following points: Low sulphur limit, more time between addition of ferromanganese and pouring, and pouring the ingots from a bottom-pouring ladle.

CLOSING BLOWHOLES IN ROLLING.—It is often tacitly assumed, in regard to ingot steel, that once a blowhole always a flaw, but Prof. H. M. Howe (Columbia Univ., New York City), does not believe this, and he endeavors to prove his point by experiments reported in a paper, "The Closing Up of Blowholes in Steel Ingots." Cutting test strips from a 9x12x45-in. ingot of 0.15 carbon at top, middle and bottom he found 10% difference in specific gravity between top and bottom. Then rolling the ingot into ½-in. plate, he took samples from the plate adjoining the notches where the ingot test-strips had been cut out, and now found only 0.2% difference in specific gravity between top and bottom samples. He argued that the blowholes, which had produced the original 10% difference must have been eliminated in part, or at least much reduced in size. Further evidence was obtained by polishing the edge of a cut cross-section of the plate, whereupon the largest of the original blowholes should have been easily visible as flat flaws or streaks, since if their volume had remained unchanged they would have been rolled out to about 0.01x1.3x 3½ ins. He found no such flaws, and indeed no prominent ones; he did find traces of some blowhole remains, but they accounted for only a small fraction of the original number. But if the holes had become reduced in size, they could not have merely compressed, for various reasons (among them the high permeability of hot steel to gases), and Prof. Howe therefore concludes that the rolling eliminated a large proportion of the blowholes. Since clean steel surfaces weld together with very slight pressure near the recalescence point, he believes that the blowholes, if they closed, also welded shut.

Prof. Howe believes that if blowholes are reduced at all in the rolling process, it should become possible to destroy all of them, by suitable development of the rolling process. He therefore deduces from his experiments that even though ingots contain blowholes, we may ultimately be able to roll steel freed from all trace of blowhole remains, i. e., sound steel.

STEEL FROM COMPRESSED INGOTS.—One of the chief methods advocated as a preventive of unsoundness is compression of the ingot during solidification. To determine whether this process is of benefit as claimed, Mr. Bradley Stoughton (Cons. Engr., New York City), collated the results of all recorded comparative tests of compressed and uncompressed steel, and set forth his conclusions in a paper, "The Physical Quality of Steel Which Has Been Subjected to Compression During Solidification." The compilation tended to prove a distinct bettering of physical quality by compression of the ingot, both in the metal of the ingot and in metal forged or rolled therefrom; but the improvement was less marked in the forged blooms or rolled shapes than in the ingot itself. The better physical quality means higher elastic limit, ultimate tensile strength, elongation, and reduction of area.

UNSOUND OPEN-HEARTH RAILS. — Mr. Robert Job (Cons. Engr., Philadelphia, Pa.) in a paper entitled "Investigation of Defective Open-Hearth Steel Rails" pointed out that the advantage of the open-hearth rail, namely, that it is tougher and can safely have more carbon through the reduction of phosphorus, is not sufficient to give good rails, but that unsoundness must be guarded against just as with Bessemer rails. He showed numerous photographs of bad open-hearth rails, revealing flaws. porosity, etc.

FAILURE OF AN AXLE FROM COARSE GRAIN.—That unsoundness is not the only trouble of steel, however, was illustrated by a paper "An Interesting Driving-Axle Failure," by Mr. M. H. Wickhorst (C. B. & Q. Ry., Aurora, Ill.). A 9½-in. driving-axle in a locomotive broke in the journal, showing an old internal crack. The metal was normal chemically, but at the center the grain was very coarse. It seems that the operation of forging the axle had refined the coarse grain of the billet only superficially, leaving a rectangular center of unreformed structure, with severe internal stresses no doubt. The author used this instance as an argument for physical tests of billets besides the chemical specification, claiming that if the billet is not good the axle can never be made good. Others seemed to hold, however, that forging with a sufficiently heavy hammer, to reach the middle of the piece, would help the trouble.

DISCUSSION.—The discussion of the various papers relating to soundness of steel exhibited a diversity of views. Speaking generally on the scientific studies, Mr. G. E. Thackray (Cambria Steel Co., Johnstown, Pa.) expressed doubt of the value of microscopic study, and on the reliability of conclusions drawn from study of failed material only; in this he was supported by Mr. W. A. Bostwick (Carnegie Steel Co., Pittsburg, Pa.), and to a considerable extent also by Prof. H. M. Howe, who in fact characterized the microscope as an instrument for seeing what you are looking for. President C. B. Dudley took middle ground in this controversy.

As to slag, Mr. E. F. Kenney (Cambria Steel Co.) claimed this to be a more general cause of trouble in rails than high sulphur, and indeed cited some of the bad rails reported which had low sulphur as an argument against attempting to hammer down the sulphur limits. Mr. C. L. Huston (Lukens I. & S. Co., Coatesville, Pa.) looks upon the large cavities with slag inclusions as the source of trouble in steel, rather than the mere bubbles or ordinary blowholes.

Another stated that 5 to 7% of the blowholes found in steel are black inside, indicating presence of foreign material, slag.

Blowholes and resulting porosity and weakness, general unsoundness, were conceded to be bad. Whether or not they can all be closed up in rolling, as Prof. Howe claimed, is a point of difference, but the present facts were concisely put by President Dudley, who said he is confident that the present metallurgical processes do not succeed in closing all blowholes. He attributes the blistering of firebox sheets to the presence of holes not closed up, and remarked that the bending test of such plate opens them up, like little mouths, with bright surface. Mr. J. P. Snow (B. & M. Ry., Boston, Mass.) said that he finds such "mouths" in rail also. Mr. J. E. Howard has found gas under pressure near the center of rolled shapes, but none near the surface; this seems to show that the elimination of blowholes is not as pervasive as Prof. Howe stated it.

Mr. R. W. Hunt (Test. Engr., Chicago, Ill.) referred to the forging or pressing of tool-steel ingots, which tends to weld shut all cavities they may contain, and deplored the fact that the manufacture of plate and shape steels does not contain a step reserved to this same welding function. Mr. J. A. Mathews (Halcomb Steel Co., Syracuse, N. Y.) stated that they use no welding process in making tool steel, and have no trouble if the steel is melted and poured properly. Mr. G. E. Thackray recalled that in attempts to make tool-steel by the open-hearth, a welding process was used, but the steel was not up to first-class crucible; possibly the metal was not dead-melted, and gas and holes resulted. Mr. James Christie (Wissahickon, Pa.) said that when the first furnaces were started at Pencoyd, the ingots were hammered, and all were solid; later a blooming mill was put in to eliminate the hammer, and the ingots were no longer solid.

President Dudley neatly turned the whole question by throwing a new light on it. He asked: Is it worth while to make better steel? The question of rails is a balance between the cost of rail and the cost of supporting the rail. However, no data as to methods or cost of better track construction and maintenance are now available. Engineers of maintenance-of-way must obtain them and so lay a foundation for answering the question. The problem will come up prominently during the next five years. And if it turns out that it will cost more to give the rail better support than to get better rail, we must get better rail.

Incidental to this matter, Mr. J. P. Snow stated in reply to Mr. Dudley's inquiry that he had found some breaks of rails on bridges, where ties were only 4 ins. apart in the clear.

As to the advantage realized from ingot compression, Prof. Howe claimed it to lie only in reduced segregation of sulphur and phosphorus, without effect on carbon segregation. He finds no other beneficial results, and in fact considers the advantage of the process to be at least doubtful, in view of poor results found with a Harmet compressed ingot at Watertown. He holds that statistics like those collected by Mr. Stoughton must be read with very great care. Mr. Howard also referred to the Harmet ingot he tested, which showed a structure having herringbone lines of weakness. He also tried the effect of cold compression (far beyond elastic limit) on steel and on limestone (with metal envelope), and found no gain in strength in either case. He therefore does not expect benefit from hot compression except what may be attained in the way of closing the blowholes. Mr. C. B. Dudley, however, sees much value in ingot-compression insofar as it makes a larger part of the ingot serviceable, and so will eliminate a large share of the early rail failures.

Cement and Concrete.

The most elaborate of the papers on cement and concrete was "Tests of Plain and Reinforced Concrete Columns," by Mr. M. O. Withey (Wisconsin Univ., Madison, Wis.) Without attempting to give the results of the author's experimental studies at present, we may refer to the fact that for columns containing both longitudinal and hooping reinforcement, the following formulas for strength are deduced:

Elastic Limit $= (1 - p)\ f_c + pf_s$.

Ultimate Strength $= (1 - p)\ f_c + pf_s + k\sqrt{p'}\,f_s'$

where primed letters refer to the hooping steel, p and f_s to the longitudinal steel. In words, the hooping is of no value up to the elastic limit of the column, but comes into action only after this point is passed, a conclusion previously advanced but still strongly combated.

BOLTS IN CONCRETE WALLS.—Mr. R. A. Cummings (Cons. Engr., Pittsburg, Pa.), felt the need of knowing what load he could hang on a steel bolt fixed horizontally in a concrete wall. He made tests for this purpose, and reported them in a paper, "Notes on the Bearing Value of Rods Imbedded in Concrete." He made blocks of concrete 10 ins. square by 24 ins. high, with a ¾-in. rod extending transversely through. Setting the block with the projecting ends of the rod resting on supports close up against the face of the block, and pressing down on the block with the head of a testing machine, he noted the load at which the concrete just above the bolt started to spall or powder away, and the load at which the deflection increased abnormally. Using both 1:2:4 and 1:3:6 concrete, both square and round rods (all of ¾-in. diameter), and testing at 35 days, he found values of about 10,000 lbs. load at yielding and spalling. The values obtained for the leaner mixture were not much lower than those for the richer concrete, though the crushing strength of the latter in test samples was three times as high.

REINFORCED-CONCRETE BEAMS; REPETITIVE LOAD.—Mr. H. C. Berry (Pennsylvania Univ., Philadelphia), continued repetitive load tests of concrete beams, of which he had reported some results at the 1908 meeting. He obtained the same results:

> One and three-quarter million applications of loads causing high working stresses in a reinforced-concrete beam [16,000-20,000 lbs. per sq. in. in steel, 500 to 640 lbs. per sq. in. in concrete] do not materially affect the ultimate strength, the maximum deflection, the bond, the position of the neutral axis, nor the amount of the ultimate deformation in the concrete.

In other words, no "fatigue" or "progressive failure" effects are apparent under the stresses noted.

ADHESION OR BOND TESTS.—To investigate the adhesion or pulling-out strength of steel bars imbedded in concrete, more fully than past experiments have accomplished, Mr. Berry arranged for three different kinds of test of this quantity, giving his results in a second paper, "Some Tests of Bond of Steel Bars Embedded in Concrete, by Three Methods." The first two methods consisted of either pulling or pushing out a ¾-in. round or square bar set vertically in the middle of an 8-in. concrete cylinder 8 ins. high. The third method employed a beam divided at the center, the bottom reinforcing rod being continuous through both halves, and a steel pin hinge being placed between the halves near the top of the section. By some extensometer tests on the exposed part of the rod it was found that the stress corresponded very accurately to that computed from the known bending-moment, and the real tests to develop the full adhesion strength of the rod were made without extensometer. The concrete in all the tests was 1:2:4 mixture, and the tests were at 28 days. The average results were, in round numbers:

> Pull-out tests, 600 lbs. per sq. in. contact surface.
> Push-out tests, 500 lbs. per sq. in. contact surface.
> Beam tests, 250 lbs. per sq. in. contact surface.

In each set there were specimens made of dry, medium and wet mixture, but no consistent differences of adhesion were found. In 7 out of 9 tests round bars gave higher values than square bars.

The low result from the beam tests is not chargeable to oblique pull, as the hinge had been ingeniously contrived, using two taper pins in taper sockets, to permit of adjustment when the beam deflected noticeably.

CONCRETE REINFORCED BY NAILS.—This was the title of a paper of Mr. L. S. Moisseiff (Department of Bridges, New York City), reporting a curious experiment. For a certain purpose where early high strength and absence of shrinkage were required of a plastic mass, it was suggested that concrete made with 8-penny nails in place of stone be tried. Actual tests of such a mixture gave really astonishing results:

6-IN. CUBES, COMPRESSIVE STRENGTH AT VARIOUS AGES.

7	days	3,000 lbs. per sq. in.
1	month	6,000 lbs. per sq. in.
2	months	6,500 lbs. per sq. in.
1	year	10,000 lbs. per sq. in.
15	months	17,000 lbs. per sq. in.

CARBON DIOXIDE AND CONCRETE.—Prof. A. H. White (Michigan Univ., Ann Arbor, Mich.), reported an unusually interesting phenomenon in his paper, "Disintegration of Fresh Floor Surfaces by the Action of Smoke Gases at Low Temperatures." Some cement floors, setting in cold weather with the aid of heat from open fires, showed abnormally slow set and later a friable surface. All ingredients appeared to be normal. Tests showed that the trouble-causing factor was the action of carbon dioxide at a temperature of about 40 deg. F., forming an unstable carbonate which easily disintegrated later. The action is only superficial, and is likely to be most noticeable on floor surfaces. But it calls for care in enclosing and heating concrete work in winter, and the author recommends that if finish coats of floors must be laid under such conditions, with open fires, the temperature be kept safely above 45 deg., and to secure quicker set, even higher.

Two other papers on cement subjects were: "Suggestions as to the Practical Use to be Made of Cement Testing," by Mr. R. K. Meade; and, "Paints for Concrete—Their Need and Requirements," by Mr. G. D. White (Patton Paint Co., Newark, N. J.). The latter touched a highly controversial subject, it appeared, and strong opinions were expressed for and against linseed oil on concrete surfaces. It was not denied that oil paints will peel if put on green concrete, say less than 6 months old, but on older concrete they were claimed to be good. As to other coatings, it appears that securing a waterproof surface is the first essential. Mr. White claimed that special materials will accomplish the desired result, giving a finish at the same time; he suggested a Chinese varnish mixed with certain other ingredients not specified. The general discussion revealed no clear knowledge on the subject, and showed no immediate promise for progress.

LOAD CONCENTRATION ON PIERS.—Whether the carrying capacity of a concrete pier is reduced by concentrating the load on part of its upper surface, and how much the reduction of strength amounts to, was studied experimentally by Prof. Edgar Marburg and reported in a paper "Some Tests of Concrete Piers under Varying Heights and Bearings." He finds that a low pier will carry almost as much when the load is concentrated on one-quarter of its upper face as when the load is distributed over the entire top.

He tested 1:2:4 concrete piers 12 ins. square in section and 12, 18, 24 and 30 ins. high. These variations of height had little or no influence on the results. The load on some was distributed over the whole top area (called "100"%); on others over a center area 8.5 ins. square, or half the face area ("50"); on others over a hollow square 8.5 ins. outside and 6 ins. inside, or one-quarter the area of the face ("25 H"); and on others over the middle quarter, 6 ins. square ("25"). The total loads which these piers could carry have the following relations, in percentages of strength developed by the full area bearing:

Top Bearing	"100"	"50"	"25H"	"25"
Total Ult. Load, % of First..	100%	70%	67%	50%

It appears from these figures that the strength of such piers is determined largely by the stress-conditions in the body of the pier, rather than by the stresses directly under the end bearing plate.

Other Papers.

TIME TESTS OF TIMBER.—The effect of long-continued dead-load on timber beams was studied by Prof. H. D. Tiemann (Yale Forest School, New Haven, Conn.) and results reported in "Some Results of Dead-Load Bending Tests of Timber by the Use of a Recording Deflectometer." Without dwelling on his interesting

curve-sheets at present, we may remark that the changes of elasticity of the wood with varying atmospheric moisture seem to enable the load to gain on the beam, so that a load which at first was carried safely broke the beam after some months.

Other papers, not above noted, include:

"The Effect of Tension on the Shearing Strength of Rivet Steel," by Prof. E. L. Hancock (Purdue Univ., Lafayette, Ind.). This showed practically no decrease in shear resistance under tension loads of ⅓ and ⅔ the tensile elastic limit, and but slight decrease with tension up to the elastic limit.

"The Desirability of Standardizing the Testing of Insulating and Other Materials, by Mr. C. E. Skinner (Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.), a stimulating discussion of a relatively uncultivated subject.

"Fuel Investigations of the U. S. Geological Survey; Progress during the year ending June 30, 1909," by Mr. J. A. Holmes (Geological Survey, Washington, D. C.).

"The Structural Materials Testing Laboratory, U. S. Geological Survey; Progress during the year ending June 30, 1909," by Mr. R. L. Humphrey (Geological Survey, St. Louis, Mo.).

"The Effect of Various Constituents of Coal on the Efficiency and Capacity of Boiler Furnaces," by Messrs. D. T. Randall and Perry Barker (Geological Survey, Washington, D. C.). This showed from a great number of tests that coals of low and high volatile content and heating value may be burned with practically equal efficiency in a properly built furnace. Capacity is a more complex matter, and generally high-grade coals have the advantage; but at extremely high rates of combustion, coals of high volatile content actually develop greater capacity than for example Pocahontas coal.

Other papers read by title only were "Some Notes on the Heat Treatment of Steel," by Mr. Wm. Campbell (Columbia Univ., New York City); three papers on rail tests and rail failures by Mr. P. H. Dudley (New York Central Lines, New York City); and "Notes on Corrosion Tests of Iron and Steel," by R. B. Carnahan, Jr. (Amer. Rolling Mill Co., Middleton, O.).

COMPETITION IN ELECTRIC-POWER SUPPLY for the city of Fitchburg, Mass., was proposed in the project to transmit power from the recently completed hydro-electric station on the Connecticut River near Brattleboro, Vt. However, it was necessary to secure permission from the Massachusetts Gas and Electric Light Commission and the decision just handed down is expected to serve as a precedent in similar cases. The local lighting company operates city lines supplied by an ordinary steam power station. The Brattleboro company is allowed to enter Fitchburg with its lines carrying energy, but it may not occupy the whole field nor duplicate the existing service of the local company. The Brattleboro company may sell power to the local company for distribution to small users for light and power and it may sell and deliver energy directly to large users.

A Railway Transfer Table Without a Pit.

By HENRY V. MILLER.*

The common type of transfer table used at car shops to carry rolling stock from one parallel track to another requires a pit extending transversely across all the tracks between which transfers are to be made. The table shown in the accompanying photograph (Fig. 1) has been recently built for the Sacramento shops of the Southern Pacific Co. As is evident from the illustration, no pit is required for this table, and foot or truck traffic across its tracks is possible at all times. It has proven itself capable of handling the heaviest materials, is rapid in motion and easily and rapidly alined on any set of rails.

This table was built to replace a transfer table of the pit type which consisted, in brief, of a wooden platform with rails and supported on axles and wheels of the common car type, the whole traveling on tracks on the floor of the pit. These tracks ran at right angles to the rails on the table itself. The table was motor-driven, the driving axles being geared to the motor in a manner much the same as on the new table. This older table formed a part of the rail connection between two of the most important shops, the locomotive-boiler and locomotive machine shops, between which a great deal of material has to be transferred. This material comes not necessarily from the two shops just mentioned, but also from other shops, which are located parallel with these two.

FIG. 1. RAILWAY TRANSFER TABLE WITHOUT A PIT.

(The I-beams supporting the floor of the table run in concrete conduits with only their upper flanges above the surface. The load is transmitted from beams to journals by "gooseneck" hangers of structural steel.)

Progress across the pit of the old transfer table for hand trucks or men with material was impossible. Whenever material on trucks had to be moved from one side of the pit to the other, a wait for the table or a long, time-consuming journey around either end of the pit was required. The pit varied from a depth at the sides of about 2 ft. to a center depth of about 3 ft., with rails projecting above the pit floor, and rendered a large area of valuable space useless except for travel of the table. Since there are 25 locomotive pits fronting on the transfer table line and an almost continuous passage of material from one side to the other, the awkwardness and poor economy of the pit transfer table is apparent. These points, together with the increased weight of new locomotives that required handling, led to the adoption and construction of the surface transfer table.

The loading with the new type of table is carried directly by I-beams spaced at intervals of 11 ft. beginning at outer lines of transfer area. Riveted to these I-beams are plates which act as stiffeners for the beams and also form the outside plates of the "gooseneck hangers" which fit over the axle boxes and transfer loadings to the axles and wheels of the table. These I-beams travel in reinforced-concrete conduits (described later on in this article) and have only their upper flanges above the surface.

Between these I-beams and forming the track of the table are channels with stiffening angles and steel bars forming the track proper, the whole being sufficiently riveted together to form a solid, stiff bearing to resist the bending moment occurring when loads come upon the table between the beams. The details of this construction are shown by the accompanying plan of the table (Fig. 2).

The conduits, of concrete, are reinforced longitudinally with old rails. The openings for the traveling of the I-beams are egg-shaped in cross-section with the curve of larger radius at the bottom and a narrow slot, of about 1-in. width, at the tops formed by rails with their bases uppermost. These rails are held to the concrete of the conduit by means of iron bars attached at regular intervals along the rails and imbedded at an angle of about 45° with the horizontal. The concrete walls are widened along one side of each conduit to form supports for the rails on which the table travels, as shown in Fig. 3. On account of the heavy load at the middle of the table when the heavier type of locomotive is carried, two rails are carried on the middle conduit with a wheel on each side of the middle I-beam of the table; and, as electrical connection for the motor driving the table is made in this middle conduit, an enlarged slot is required with resulting heavier concrete construction.

Electrical contact is made by the use of an ordinary trolley-wheel which, instead of bearing against the trolley from beneath, carries the wire on its upper edge. As wheel and table move along, the wheel raises the trolley-wire from the insulators on which it rests, the wire falling back on the insulators as the wheel passes. The insulators are of wood, cone-shaped and fastened to the sides of the conduit at intervals of about 10 ft. These conical insulators are placed in pairs with an additional glass insulator fastened betwen the two apices. When the trolley-wire drops as the wheel passes, it is automatically centered again, as is evident from the preceding description.

Power for operating the table is supplied by a 25-HP. motor which is geared to the driving axles, as shown in Fig. 2. The motor is regulated by a controller of the type used on trolley cars and a clutch for the gears is operated by a lever on the right of the motor. This lever, which may be seen in Fig. 1, is used for controlling the motion of the table, while the lever on the left side of the controller operates the clutch connecting the motor to the drum on which is wound a wire cable for pulling material on or off the table.

The upper surfaces of the rails on the table are about 7 ins. above the plane of the rails on which the table travels. This necessitates a slight grade in the track leading from the shops to the table. As it was originally intended to run tracks across the transfer-table tracks in several places for through traffic, the incline of the tracks leading to the transfer table necessitated some arrangement for raising them and lowering them again to grade. To do this, the automatic apron shown at the left in Fig. 3 was devised. On the outside face of the outside set of I-beams will be noticed (Fig. 2, elevation) an angle fastened horizontally between the tracks of the table and inclined at either end. As the table approached a set of tracks, the tracks were carried up the inclined portion of the angle fastening bringing the tracks on and off the table into alinement so that the same level existed at their ends. As the table passed by, the rail ends were lowered again to their normal position for travel across the through tracks. The jointed portion of track extended back a distance of about 15 ft. from either side of transfer table line.

The use of the outer automatic apron with this particular table was abandoned for several reasons. The gravel comprising the surface between the rails of the table would get into the space beneath the rails leading to the table and prevent their lowering into place again, necessitating a constant clearing on this account. These rails were cross-braced with wrought-iron bands, and any foreign material under these

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braces had the same effect as foreign material under the rails themselves. The main trouble encountered was the bending of the rails, when in the raised position, by the passage of a heavy locomotive over them.

In the original design, flat-rimmed wheels were used. It was found, however, that alinement of the transfer table could not be maintained with these wheels, and, as a result of this, the webs of the I-beams became worn, owing to friction against the edges of the rails forming the slots in which the beams travel. The substitution of flanged car wheels has resulted in perfect alinement of the table and the wear on the web of the I-beams (a very dangerous matter) has been reduced to zero. There is, of course, a depression along the edge of each rail, formed by the flanges of the wheels, which did not exist with the other type of wheel, but its existence does not obstruct to any considerable extent the ready travel across the table's path.

The table described was designed for the Sacramento shops of the Southern Pacific Co. by Mr. F. S. Edinger, of the Shattuck-Edinger Co., engineers and contractors, of San Francisco and Los Angeles, and patent office claims have been allowed on all its principal features.

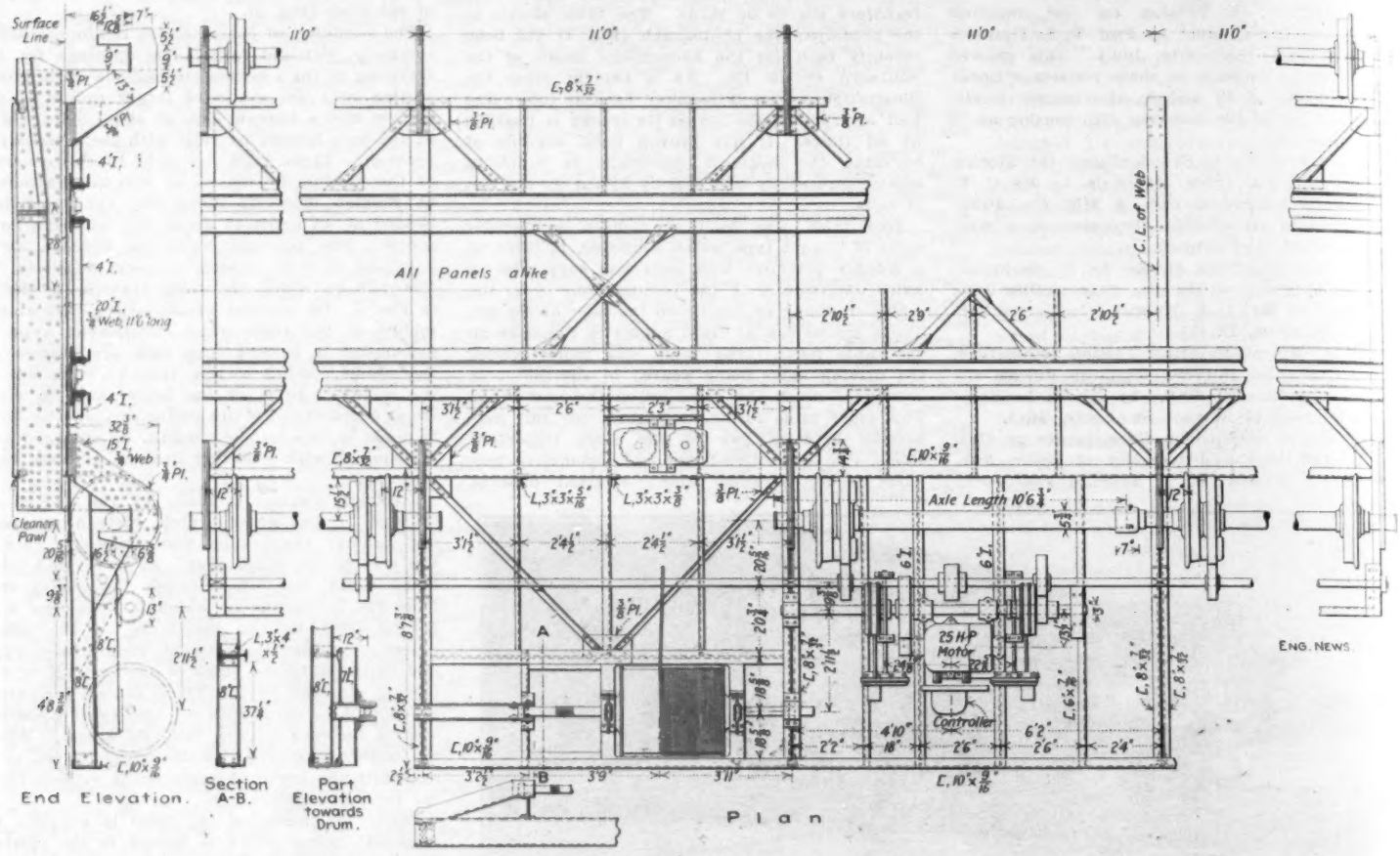

FIG. 2. STRUCTURAL DETAILS OF SURFACE TRANSFER TABLE.

(Designed by F. S. Edinger for the Sacramento shops of the Southern Pacific Co. The table as built differs from the drawing in having wheels on each side of the middle I-beam, as shown in Fig. 1.)

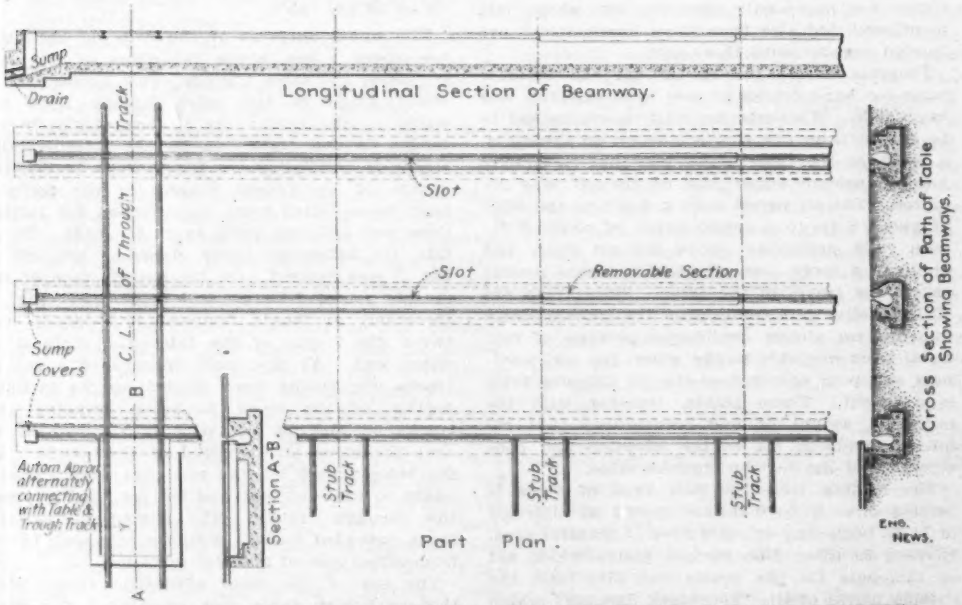

FIG. 3. PART PLAN OF PATH FOR SURFACE TRANSFER TABLE; SHOWING CONCRETE BEAMWAYS AND AUTOMATIC APRON.

(The automatic apron was abandoned in the case of the Sacramento table for reasons explained in text.)

Conservation of Our Artesian Water-Supply.

By FREDERICK G. CLAPP.*

One of our rapidly decreasing natural resources in certain sections, which has been too little emphasized as yet, is the artesian water-supply. Although water is more abundant than any other mineral, although surface water has been considered in all its aspects, and artesian supplies which form flowing wells exist underneath large areas of country, underground water has been hardly mentioned in the reports of the Conservation meetings in Washington. The more is this to be deplored for the reason that there is a real danger, imminent in many regions, that the underground water-supply which is tapped by wells will decline to such an extent as to be of little value as an economic asset to the community.

The portions of the country in greatest danger of such a loss are the areas where the underground water exists in certain deeply-buried formations under such great hydrostatic pressure that it will rise and overflow the surface when tapped by the drill, forming a flowing *artesian well*. Such areas are known as *artesian areas* or *artesian basins*.

AMOUNT OF UNDERGROUND WATERS.—In order to understand the situation, it is necessary to review the value of underground water to the community. By *underground water* is meant the sum total of the water which exists below the surface of the ground, whether confined to definite channels, or distributed through a mass or stratum of porous rock or other materials. Underground water is the water which is tapped by shallow, deep and artesian wells, and which overflows in springs. This mass of water is much larger than is commonly supposed, the total amount of free water in the earth's crust being equivalent to a sheet of water from 100† to 7,500‡ ft. thick, according to various

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†M. L. Fuller, Water Supply and Irrig. Paper No. 160, U. S. Geological Survey, 1906, p. 72.

‡Achule Delesse, Bull. Soc. Geol. France, 2d Ser., Vol. 19, 1861, p. 64.

authorities. The first-mentioned of the two estimates is believed to be more nearly the truth than the second. The porosity of the earth's materials ranges all the way from 0.16% of their volume in the case of some granites* to 53% in the case of chalk.† Many sands and sandstones have porosities of 20 to 50%. It is thus evident that large amounts of water are contained in the ground below the upper limit of saturation, and these are the supplies that are commonly obtained in wells.

Where a formation is particularly productive as a water-bearer, the number of wells drilled to it is generally large, and these constitute a heavy drain on the underground reservoir of water. Spring waters are not looked upon as a loss to be deprecated, for the reason that they constitute natural overflows which keep the water at constant level. Every well, however, takes away part of the general supply; and the increase in number of wells and amount of water drawn from each individual well acts in a manner similar to the draft of a town of increasing population on the surface reservoir supplying it.

The amount of artesian water and the extent and number of artesian basins are also greater than is commonly supposed. It is estimated that half of the State of South Dakota is underlain by water which will overflow the surface, one-fifth of Mississippi and Louisiana, one-tenth of Georgia and Florida, one-fifteenth of Alabama, one-twentieth of Texas, one twenty-fifth of Michigan, and large areas in other States, notably Long Island in New York, New Jersey, Maryland, Virginia, North and South Carolina, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Arkansas, Colorado, Wyoming and California are similarly underlain. The wells in these States, wherever they are left open to overflow of their own will, constitute a more serious draft on the general water-supply than do wells which are pumped.

USES OF UNDERGROUND WATER AND ARTESIAN WATER.—Artesian waters have a multitude of uses, their greatest value probably being as a source of domestic and stock supply in the farming portions of the country. Hundreds of cities and towns obtain their entire supply from deep and artesian wells drilled into rock. Thousands of manufacturing and other industrial plants have wells for their supply. Railroads draw water at thousands of tank stations from deep or shallow wells. One of the most extensive uses of underground waters is for irrigation, and in the central and western States millions of acres are irrigated by flowing or pumping wells. This is done on a smaller scale in nearly every State in the country. It is in the areas where artesian water is used in part or entirely for irrigation that the decline of the supply is most noticeable.

DECLINE OF UNDERGROUND WATERS.—The decline of the underground water-supply has been studied carefully by the writer in central and northern Indiana, in connection with investigations made in 1907 and preceding years for the U. S. Geological Survey. The northern part of that State is largely a flat plain, consisting of glacial drift varying in thickness from 10 to 500 ft. overlying the Niagara limestone and other formations.

Normally the water level lies near the surface, but it has been falling off, and has declined on an average of 15 to 25 ft. in the past 25 years. For this reason many people in the country districts who use open wells have found it necessary to deepen the wells or to change from open wells to driven or drilled wells.

There is another way in which the decline of the ground water-supply can be proved; that is, by observations on flowing wells, and on water flowing to waste from the casings of old gas wells. People who are familiar with these wells know that many which were drilled years ago have now ceased to flow entirely, and almost every such well has diminished appreciably within a few years. This statement is true particularly in Madison, Delaware, Henry, Hamilton, Tipton, Grant and Howard counties, Indiana, but also elsewhere. All water-works engineers and superintendents in this state know that they have had to install new wells more rapidly than the population has increased. All evidence shows that the ground water level is slowly subsiding.

DECLINE OF UNDERGROUND WATERS IN OTHER STATES.—A similar decline has been observed in the artesian well districts of Florida, where the head of deep flowing wells in certain sections along the east coast and the St. John's River has declined notably.

In southern Michigan* a decline of the underground waters has been recorded through the investigations of Sherzer and Fuller. Previous to the year 1900 it was noted that the flow of many artesian wells stopped during a drought, the water in many non-flowing wells became lower, that the opening of certain wells frequently affected others in the neighborhood, and that the artesian areas were contracting year by year. The decline has continued to the present time. During the year 1904, in addition to the general decline, Fuller noted a more marked falling off, due to special causes.

In all the important artesian basins of Southern California Mendenhall† has observed a similar decrease in area. In the coastal plain artesian area, which in 1894 was 290 sq. mi. in extent, 2,500 flowing wells had been drilled up to 1904, and the size of the basin had decreased to 190 sq. mi. In this basin are hundreds of pumping plants, also making heavy drafts on the water.

At Chicago, Ill., the first flowing artesian well was drilled in 1864, and water rose to a height of 80 ft. above the surface, or 111 ft. above Lake Michigan. This flow has long since ceased, and the head has so declined that now the water stands 15 to 20 ft. *below* the surface, or 100 ft. lower than its original head. In the past there have been a great many flowing wells in Chicago, but the number of wells drilled has been so great and the drafts upon the water-bearing strata are so heavy that at present a flow can rarely be obtained.

CAUSES OF DECLINE.—The causes of the decline of underground waters are various, and differ somewhat with locality; but in all localities certain common causes prevail which are operating toward the same end. In order of importance these are believed to be somewhat as follows:

(1) Deforestation.
(2) Waste of water.
(3) Surface drainage by ditching and tiling for cultivation.
(4) Overdevelopment of the underground water-supply.
(5) Underdrainage by quarries, mines, sewers and tunnels.
(6) Deficiency of rainfall in certain years.
(7) Early frosts in the fall.
(8) Leakage from casings into porous strata.

In some localities the decline in the flow of individual wells results from a clogging of the pores in the water-bearing formation, or the deposition of mineral matter about the bottom of the pipe; but this is not due to any decline in the general supply of water.

Over-development is unquestionably responsible for loss of head in some localities. This has been observed by the writer in the truck-raising districts along St. John's River at Sanford, Fla., where wells have been drilled on nearly every lot of land in the town and vicinity, and the head of water in the flowing wells has declined seriously. Over-development may cause decline by drawing off water in such quantity that the overflow or pumping excels the annual additions from rainfall to the water-bearing formation.

Over-development probably has been carried to the greatest extreme in southern California. In that state the rainfall of the ten years immediately preceding 1904 was 25% below the normal, and hence a part of the decrease is attributable to that cause. But that this was not the main cause is shown by the fact that during two years directly preceding 1903 the rainfall was above the average, in spite of which the water level nevertheless continued to fall.

DEFORESTATION.—In Michigan, Fuller attributed the sudden decline in 1904 to conditions brought about by the deforestation of the land, drainage by ditches, early frost, which prevented rain entering the ground, and the deficiency of rainfall in that year. Fuller states, however, that the general decline which has been going on for over 20 years is due mainly to the inevitable deforestation, as the country became older and the forests gave place to farms.

Through the central states deforestation has long since removed the natural storage cover of the land, and rain water which formerly was held for days, weeks or months in the surface deposits now runs off during a storm and within a few hours it finds it way to the nearest stream. These swell for a day or two, but quickly subside. The injury done by the removal of the forests has been observed at Eaton, Ohio, where springs which formerly supplied the town with water diminished in flow so as to be insignificant shortly after the removal of several acres of timber on the surrounding drainage area. It is well known that many hillside springs in eastern United States which once flowed copiously have now run dry.

The harm caused by removal of the forests is largely irrevocable, but this circumstance leads us to the consideration of the second main factor causing the decline in artesian water.

WASTE OF ARTESIAN WATERS.—The second great cause of the decline is one which could have been prevented, and can still be remedied to a considerable extent by proper procedure. In Indiana many flowing wells have been personally visited and the most conspicuous fact noticeable everywhere was the recklessness with which the ground-waters are wasted. In driving through Madison, Delaware, Henry, Hamilton, Tipton, Grant, Howard and other counties, hundreds of wells were seen from which the pure water from the Niagara limestone formation was flowing to waste on the surface. More than half the flowing wells in these counties were originally drilled for oil or gas. In such wells the drive pipe is sunk to the top of the limestone, and the casing inserted inside to the bottom of the limestone. The water rises between the drive pipe and the casing, and overflows at low point along valleys or other depressions in the surrounding plain. Normally, the Niagara limestone is 200 to 500 ft. thick, and the flow from it in individual wells ranges from 1 to 600 gals. per min.

In Madison County, the flowing wells are most numerous along Fall Creek, Lick Creek and White River. A conservative estimate of the number of flowing deep wells in that county is placed at 100. The usual volume of flow is 5 to 20 gals. per min., but many wells yield more than this, and probably bring the average up to at least 20 gals. On this assumption the amount of water wasted every minute in Madison County alone is 2,000 gals. If this all were concentrated in one place it would be ample to supply a city of at least 30,000 inhabitants. In some counties single wells have been seen which alone would supply half this number. Of course if the loss by these hundred wells were distributed over the entire state or even over the entire county it would be infinitesimal in amount at any particular point; but we should remember that the waste is centralized along certain valleys where flowing wells are most abundant. Moreover, this water is not derived from some distant "inexhaustible" source like Lake Erie, as some persons have assumed, for in that case the water would be obliged to run up hill. Nor is any part of it presumably transmitted from the high lands in Ohio, because, under such assumption, the land, which is high enough to give the necessary head, and which only covers a portion of a single county, would soon be drained dry. On the contrary, nearly all water from deep wells in the Niagara limestone is derived from the rainfall within a very

*E. R. Buckley, Bull. Wis. Geol. Survey, No. 4, 1898, pp. 400-403.
†A. Geikie, Text Book of Geology, Vol. 1, p. 410.

*W. H. Sherzer, Geol. Surv. of Mich., Vol. 7, p. 94. M. L. Fuller, Water Supply and Irrig. Paper, No. 145, U. S. Geol. Survey, 1905, pp. 129-147.
†W. C. Mendenhall, Water Supply and Irrig. Paper No. 139, U. S. Geol. Survey, 1905, pp. 16-18.

few miles or even a few hundred feet of the well, where it penetrates the drift and enters the porous limestone below. When a well is drilled, if its elevation is not too great, the pressure of water in the overlying drift transmitted to water contained in open channels in the limestone, causes the latter to reach the surface and we have a flowing well.

Water is wasted in other ways, as witnessed by the sad fact that, while 40 gals. per capita should be ample for all needs in an ordinary city without much manufacturing, most city waterworks are daily pumping several times this amount. For this evil the meter is the remedy; as there is no logical reason why an individual should not pay for the actual amount of water he uses, as he does in the case of gas or electricity. Careful investigation of city water-supplies in Indiana, Ohio, Maine, Minnesota and Florida have made the writer an advocate of the meter system.

In the Roswell artesian area in New Mexico, as stated by Fisher,* it is common to allow most of the water overflowing from the artesian wells to run to waste into pools or into marshes or rivers. In South Dakota hundreds of flowing wells are allowed to run to waste; and while in that region the Dakota sandstone formation furnishes a supply of water which has not been observed to decrease, such a danger is imminent with the rapid multiplication of wells. Moreover, in many localities where wells have been drilled for irrigation, a subsequent sufficient rainfall has now rendered them unnecessary.

GENERAL REMEDIES FOR DECLINE.—Various remedies for the decline of wells have been proposed locally, as follows:

(1) Cleaning the wells.
(2) Deepening the wells.
(3) Changing from dug to drilled or driven wells.
(4) Renovating the wells.
(5) Decrease in number of wells.
(6) A more economic distribution of wells.
(7) Decrease in the amount of water used.
(8) Prevention of waste by legislation.

The first four factors are remedies for the decline of water in any particular well, or group of wells, but not for the conservation of the supply. The latter must be accomplished either by the decrease in the number of wells or by decrease in the amount of water drawn from them. The decrease in the amount of water used must be accomplished in the case of flowing wells by capping the wells, or providing valves to regulate the flow, as is now done in some states. Well owners in general are prejudiced against decreasing the flow in this way, claiming that the well will be damaged in consequence of clogging with sand, as has happened in some places. Where that is the case, as in Florida and New Mexico, it has generally been on account of poor construction. In any case, the greater part of the water-supply can be shut off without danger of serious clogging. The danger can generally be avoided by the gradual closing of a well. And if it should become clogged notwithstanding all precautions, it can be reopened by lowering an iron rod and churning up and down until the flow is started.†

In some cases it may be practicable to close the wells over Sundays, or during the winter. The economic advantage of giving wells a rest is shown by the fact that wells in the vicinity of the Chicago stock yards flow only for a brief period each week, after the usual Sunday intermission from pumping.‡ The writer is familiar with a well in the city park at Marion, Ind., which is fitted with a pump during the week, but on Sundays, when the pumps of a large manufacturing plant three-quarters of a mile distant are not working, this becomes a flowing well. In all these cases a few hours rest proves sufficient to accumulate a supply of water sufficient to raise the head and pressure, and several months' accumulation would undoubtedly make considerable difference with the supply of water immediately available.

A full conservation of the ground water-supply is, of course, impossible; because of the constantly increasing need for its use. We can not interfere with the right of a well owner to a reasonable use of water if it is all going to serve a useful purpose. But for the reason that new wells are continually being drilled by parties demanding a similar supply, we ought not to allow water to be wasted. Legislation should be enacted providing that all flowing wells (whether originally drilled for water, for oil, or for gas) should be capped or otherwise shut off when not in use; and when in use a stream of only the requisite size should be allowed to flow.

Even if the amount of water were infinitesimal when compared with the total underground supply, the very act of putting it to some use would be an economic gain to the community. Where flowing wells are situated along creek bottoms below houses, rams can be installed and the water made available for domestic purposes by raising it to the plains above, as is sometimes done. The formation of reservoirs, fish ponds, bathing pools, or drinking places for cattle would be a great improvement on the common indifference to waste.

LEGISLATION AS A REMEDY FOR DECLINE OF ARTESIAN WATER-SUPPLY.—A number of states in the country have already realized the importance of forbidding waste of water from wells, and California, Colorado, Michigan, Nebraska, South Dakota and Washington have enacted laws to that effect.* The California act was passed as long ago as 1878, and is a fair sample of what such acts should be. (Laws of 1877-78, p. 195.) It provides

(Section 1) Any artesian well which is not capped or furnished with such mechanical appliance as will readily and effectively arrest and prevent the flow of water from such a well is hereby declared to be a public nuisance. The owner, tenant or occupant of the land upon which such a well is situated who causes, permits or suffers such public nuisance, or suffers it to remain, or continue, is guilty of a misdemeanor.

(Sec. 2) Any person owning, possessing or occupying any land upon which is situated an artesian well, who causes, suffers, or permits the water to unnecessarily flow from such well or to go to waste, is guilty of a misdemeanor.

The laws of Colorado respecting the use of artesian waters and in prohibition of their use are much the same as those of California. The specific act was approved in 1887 (Laws of 1887, p. 52) and provides:

(Secs. 1 and 2). Any artesian well which is not tightly cased, capped, or furnished with such mechanical appliances as will readily and effectively prevent the flow of water from such a well is hereby declared to be a public nuisance. The owner, tenant, or occupant of the land upon which such a well is situated, who causes, permits, or suffers such public nuisance, or suffers or permits it to remain or continue, is guilty of a misdemeanor.

Any person owning, possessing or occupying any land upon which is situated an artesian well, who causes, suffers, or permits the water to unnecessarily flow from such well, or to go to waste, is guilty of a misdemeanor.

For the purposes of this act an artesian well is defined much the same as under the California law, above cited, except that it is provided that nothing in the act shall apply to water flowing from mining shafts, and the definition is made to read, "the waters of which, if properly cased, will flow continuously," etc.

Waste is confined as in the California law, with a few minor modifications in the wording, and with the provision that the use of the water for agricultural purposes is allowed in addition to the other uses enumerated above.

A fine of not less than $50 nor more than $300, together with the cost of prosecution, is assessed against anyone violating any of the provisions of the act. The county commissioners, road overseers, city engineer, or city officers are empowered to investigate and prosecute alleged violations of the act.

In Michigan the provision is more moderate (Laws of 1889, p. 221), as follows:

No person or persons, or corporation other than municipal corporations, owning or operating any artesian well, shall allow the same to flow a larger stream than will flow through a pipe 1 in. in diameter, to the detriment or injury of any other well or wells, without the consent of the owners of such well or wells so injured.

Any person or persons who shall suffer any damage because of the violations of the provisions of this act shall be entitled to recover the same from the person or persons or corporations so causing the same, the action of trespass of the case to be brought in any court of competent jurisdiction.

This act shall not apply to salt, oil, mineral water, or gas wells, or wells leased for bath purposes.

The act in force in the State of Washington was passed in March, 1901, and is as follows: (Laws of 1901, p. 259.)

(Section 1). It shall be unlawful for any person, firm, corporation, owner, lessee, agent or manager, to allow or permit water to flow or escape from such a well between the first day of October in any year and the first day of April next ensuing: *Provided*, That this act shall only be applied to sections and communities wherein the use of water for the purposes of irrigation is necessary or customary; *And provided further*, That nothing herein contained shall prevent or prohibit the use of water from such a well between the first day of October and the first day of April next ensuing for household, stock, and domestic purposes only, water for the last-named purposes to be taken from such well through a ½-in. stop and waste cock to be inserted in the piping of such well for that purpose.

(Sec. 2) It shall be the duty of every person, firm, corporation, or company having possession or control of any artesian well as provided in section 1 of this act to securely cap the same over, on or before the first day of October in each and every year, in such manner as to prevent the flow or escape of water therefrom, and to keep the same securely capped and prevent the flow or escape of water therefrom, until the first day of April next ensuing: *Provided, however*, It shall and may be lawful for any such person, firm, corporation, or company to insert a ½-in. stop and waste cock in the piping of such well and to take and use water therefrom through such stop and waste cock at any time, for household stock, and domestic purposes, but not otherwise.

(Sec. 3) Any person, whether the owner, lessee, agent or manager, having possession of any well, violating the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in any sum not exceeding $200 for each and every such offense, and the further sum of $200 for each ten days during which such violation shall continue.

(Sec. 4) Whenever any person, firm, corporation, or company in possession or control of an artesian well shall fail to comply with the provisions of this act, any person, firm, corporation, or company lawfully in possession of the land adjacent to or in the vicinity or neighborhood of such well, and within five miles thereof, may enter upon the land upon which such well is situated and take possession of such, from which water is allowed to flow or escape in violation of the provisions of section 1 of this act, and cap such well and shut in and secure the flow or escape of water therefrom, and the necessary expense incurred in so doing shall constitute a lien upon said well, and a sufficient quantity of land surrounding the same, for the use and operation thereof, which lien may be foreclosed in a civil action in any court of common jurisdiction, and the court in any such case shall allow the plaintiff a reasonable attorney's fee, to be taxed as a part of the cost. This shall be in addition to the penalty provided for in section 3 of this act.

In South Dakota a great deal of legislation pertaining to artesian wells has been enacted since 1889. The section dealing with Conservation is as follows (Laws of 1901, chap. 80, sec. 42):

Any person, association, or corporation owning land shall have the right to sink or bore an artesian well or wells on his, their, or its lands, for the purpose of procuring water for domestic use, for irrigation, or for manufacturing purposes; but in wells hereafter constructed no more water shall be appropriated by such person, association, or corporation than is needed for said purposes, when such additional use of water interferes with the flow of wells on adjacent lands.

A section of the South Dakota act provides for the sinking of artesian wells upon petition of the majority of the voters in any township in which wells and lands to be benefited are to be located. The acts of this state also show scientific foresight in a provision for the distribution of wells in such a manner as to properly equalize the use of water, by causing the least possible interference with one another, as follows:

(Sec. 43) In locating wells in townships which have established and put down wells under the provisions of this act for public use or by private parties, due regard shall be had to their proper distribution, in order that the flow of the wells may be properly equalized and least likely to interfere with each other. Should any well in such township, public or private, be located so near any well already completed or in process of completion as to be likely to interfere with the same, any person may complain in writing to the State Engineer, who shall without delay proceed to examine the locality and determine from its topography and the proximity of the wells whether, in his judgment there will be no material interference, the location will not be changed, but if in his opinion the well as located will materially interfere with the one completed or in course of completion he shall change the location of said well to some more suitable locality; provided, that when permanent buildings have been located on any farm prior to the sinking

*C. A. Fisher, Water Supply and Irrig. Paper No. 158, U. S Geol. Survey, 1906, p. 25.
†J. E. Todd and C. M. Hall, Water Supply and Irrig. Paper No. 90, U. S. Geol. Survey, 1904, p. 43.
‡Frank Leverett, Seventeenth Ann. Rept. U. S. Geol. Survey, 1896, Pt. 2, p. 787.

*D. W. Johnson, Relation of the Law to Underground Waters, Water Supply and Irrig. Paper No. 122, U. S. Geol. Survey, 1905, pp. 39-49.

of any artesian well on any adjoining farm, this act shall not be construed as prohibiting the agent or proprietor of said farm from sinking an artesian well at or near said building without reference to the proximity of any other artesian well. The State Engineer shall, within five days after said examination, make a written statement of his decision and file the same or a copy thereof in the office of the circuit court of the same county wherein the said wells are located. Any person aggrieved by the decision of the State Engineer may, within ten days after the filing of the decision in the office of the clerk of the circuit court, appeal from the same to the circuit court and upon such appeal the question shall be tried de novo.

In order to determine the amount of water flowing from a well, the State engineer is required (Laws of 1891, sec. 44):

To measure or to cause to be measured the flow and pressure of all artesian wells established and put down under the provisions of this act, public and private, at such times as he may deem proper, for the purpose of determining the increase or diminution of the flow or pressure of said well, and is hereby authorized to enter upon any grounds for the purposes aforesaid, and the owner or owners of such well or wells are hereby directed to furnish the necessary material to construct a suitable weir to measure the flow, and all reasonable conveniences shall be afforded for this purpose.

In California the law to prevent the waste of water led to a suit by J. L. Elam to test its legality.* The petitioner had been fined for a violation of the act, and applied for a writ of habeas corpus, alleging that he had been deprived of his liberty for non-payment, and claiming that the State, in imprisoning him, had violated certain articles of the Constitution of the United States and of the State Constitution. The law of the case in all its bearings was reviewed by the court and the writ denied. The decision was summarized in the statement of Judge Allen that "legislation directed to the conservation of such water is not prohibited by any constitutional provision."

CONCLUSION.—In conclusion it may seem timely to remark that similar laws are necessary in other states. Such legislation should go hand in hand with legislation to improve our streams. If we continue to allow our rivers to be polluted by sewage and by oil well and factory waste; and recklessly waste our underground waters, which are the only other available supply, where is the next generation to get its water? The writer believes that the answer to this question lies with the present generation rather than the next, and that the enactment and enforcement of the needed legislation, in addition to the practice of intelligent means for conserving the supply in individual wells, is the solution of the problem.

THE WITHDRAWAL OF TELEPHONE SERVICE from a subscriber, who had violated two rules of the telephone company by (1) freely expressing his opinion of the central operator's attentiveness and (2) by habitually listening to the conversations of other subscribers, has been declared illegal and unjustified by the Iowa Supreme Court in a test case. It was held that the company had exceeded its power, presumably in imposing a penalty out of proportion to the offense.

DUST IN COAL MINES.—In a paper, "Electricity in Coal Mining," before the Coal Mining Institute of America, June 29, Mr. G. R. Wood, of Pittsburg, Pa., quoted the results of investigations by a Mr. Randolph, formerly of the Pittsburg Coal Co., into the production of dust by different undercutting machines. The figures are given below and have been reduced to pounds of dust produced per sq. ft. of coal undercut. The "dust" is that part passing a 40-mesh screen.

Commencing about the time of the Naomi, Darr and Monongah explosions, there has been a general house-cleaning regarding greater safety in mining operations. About this time it began to be definitely decided by a large number of practical mining men that dust was a large factor, if not the initial one, in some mine explosions, and the chain machine, which is almost universally motor-driven, was blamed for producing a large amount of dangerous dust.

At the mines of the Washington Coal & Coke Co., on the lower edge of the Connellsville region, investigation showed the following production: By hand mining, 1.80 lbs. per sq. ft. By puncher machine, 4.58 lbs. per sq. ft. By chain machine, with pick-pointed bits, 1.48 lbs. per sq. ft.

At the mines of the Westmoreland Coal Co. the puncher machine gave 6.18 lbs. and the chain machine, with the standard chisel bits, gave 2.43 lbs. of dust.

At the mine of the Pittsburg Coal Co., Midland No. 1, the chain machine gave 2.43 lbs. and 2.51 lbs. at two different trials, and the puncher machine gave 6.18 lbs.

There is no disputing that the average coal cut by the chain machine will be smaller than that cut by the puncher or by hand, but the amount of coal cut out in undercutting by the puncher is so much greater than the amount taken out by the chain machine, that the actual amount of dust will be greater, as given above.

*Eng. Record, Vol. 56, Nov. 9, 1907.

Notes from the Report of the Board of Public Works, Louisville, Ky.

The report of the Board of Public Works of Louisville, Ky., for the year 1908 touches upon a number of points of general interest. One of the first of these is the attempt of the city to secure a municipal asphalt repair plant. Thus far this attempt has been unsuccessful, through litigation over land for a site for the plant. The report states that the city has been forced to pay $12 per ton for hot asphalt delivered on the street for its repair work, or $10 per ton for the asphalt at the mixing plant of the company.

The advantages of planning municipal work well in advance are dwelt upon in the report. By this means, the Board has effected considerable saving in contract prices through having its contracts ready to let before contractors were loaded up with work. Letting contracts early and giving the contractors plenty of notice of the letting is also advantageous to a city, since it affords the contractors plenty of opportunity to look over the ground and make estimates for work.

An extension of the principle of planning work in advance so as to lay out street work for some four years ahead, is also discussed in the report.

The comparative cost of city and contract paving work in Louisville in 1908 was decidedly unfavorable to doing the work by the city. The comparison is considered an unusually fair one, since the work done was "in the same locality, of the same construction, and under like circumstances." Sheet asphalt on a 6-in. concrete foundation cost $2.21 per sq. yd. for a single block laid by contract, against $2.71 for about ten blocks laid by the city. The excess cost of city work was therefore 50 cts. per sq. yd., or 20%. For granite block pavement, also on a 6-in. concrete foundation, the contract work cost $2.57 per sq. yd., and the city work cost $3.11. This was an excess of 54 cts. per sq. yd., or 21% for the city work. In view of this showing, the report states, the Board has decided to do most of its pavement reconstruction in 1909 by contract.

Two paragraphs on cold asphalt pavements are here quoted in full:

A new experiment made by the Board of Public Works was the construction of cold asphalt pavement. Upon a course of large broken stone and screenings, well rolled, is placed 2 ins. of broken stone of smaller size, not exceeding 2½ ins. in any dimension. Upon this top course of stone is spread 1 ton of asphalt to every 25 sq. yds. of pavement. This asphalt should contain not less than 7% bitumen. Asphalt with less bitumen has been tried by this Board and does not give good results. The asphalt is then thoroughly rolled with a view of compressing it and the top course of broken stone together and making a waterproof covering to the street.

Several streets were reconstructed in this manner during the fiscal year 1908. They have given good results except where there are car tracks in the streets. A cold asphalt street compresses and improves by usage. Travel over it rolls it more and more compactly and puts the surface in a better condition. It is believed that this kind of street will never give entirely satisfactory results where there are car tracks, because it is impossible to give it its final compression with a roller. Usage rolls it down more solidly and places it below the street car rails, and it is not possible to repair the street along the rails so as to make an altogether acceptable job.

Sewer cleaning by means of a machine consisting of buckets drawn through the sewer from manhole to manhole, is described as an improvement recently made. Sewers as small as 12 ins. in diameter "can be thoroughly cleaned" in this way. Heretofore, the report states,

sewers under 18 ins. have been cleaned only as far as they could be reached by rods from the manholes. These smaller sewers have in time become so thoroughly stopped up as to be practically useless. They are now being opened up by the use of the sewer-cleaning machine and made available.

A second machine has been ordered. The name of the maker of the machine is not given in the report.

Garbage and refuse disposal is discussed in the report. The Board recommends an incinerating rather than a reduction plant, and estimates that three or more plants, with a combined daily capacity of 300 tons, located in different parts of the city, would be sufficient until a population of 300,000 is reached. The engineers of the Board and of the Louisville Water Co. (really a municipal plant) are of the opinion that it would be mutually advantageous if electricity were generated at refuse destructors and transmitted to the water-works pumping station for use there. It is estimated that steam capable of producing 1,500 HP. could be produced. The Board recommends that the city take immediate steps to provide a sufficient number of high-temperature destructors "to dispose in a decent and sanitary manner of the daily output of ashes and garbage."

The Board reports one change that it made on taking office, which relatively few public boards have the courage to venture upon. This was the reduction of team hire from $4 to $3.50 per day. By this means the saving in the Street Cleaning Department alone was $9,319.

The method of keeping street-cleaning statistics in Louisville heretofore is described in the report as "absurd," since under it it is not possible to tell the cost of street cleaning or of the collection of ashes and garbage. Reform in this particular was instituted during the year. Further reforms are needed in order to secure comparative unit-cost figures for cleaning pavements and catch-basins and for removing ashes and garbage. One of the details of the reform instituted has been the use of

a card catalog showing the number of square yards in each block of street and alley in Louisville, and the material of which the pavement is constructed.

The manner in which the Board of Public Works is handicapped through unfortunate limitations on the salaries to be paid members of the Engineering Department, together with recommendations for improvement in this particular and also in the personnel of the Board of Public Works, is set forth in a few paragraphs, which may be suggestive and helpful to city officials elsewhere and are therefore quoted as follows:

The Engineering Department of the Board of Public Works has the supervision of the expenditure of over a half million dollars of money every year, yet the Chief Engineer's salary is only $3,000 a year, and the Board of Public Works is forbidden by the city charter to pay more than $1,500 per annum to any employee, except the Chief Engineer. It is impossible to get an efficient engineering corps when no assistant engineer can be paid more than $1,500 per annum. Men of education and experience in the engineering profession cannot be obtained for such a salary, and without such men the problems which confront the Engineering Department cannot be solved in a manner that will give satisfaction to the public. Without a sufficient number of educated and experienced men the ordinary routine work of the Engineering Department, which the public wants and wants promptly, cannot be done without the most aggravating delays.

The most important thing that the city can do to help in the speedy and thorough restoration of its streets is to secure from the Legislature the repeal of the charter provision restricting the salaries under the Board of Public Works to $1,500 per annum. The Chief Engineer ought to have two assistants at $3,000 and $2,000, respectively, and the Chief Engineer himself ought to receive $5,000 per annum.

With the officers now at the Chief Engineer's disposal almost every question must ultimately be passed on by him. The result is a mass of work which it is physically impossible for one man to do. The consequence is that work is delayed, the city put to an expense and the public is dissatisfied with the delay in giving attention to their just complaints.

Recommendations Made.

We have made an earnest endeavor to improve the organization of the departments under our control and have given much thought and time to that end. While something has been accomplished, much undoubtedly remains to be done, so much indeed that we feel that at least for the next few years the Board of Public Works should have upon it one member who can give his entire time to the city. We would, therefore, recommend that a competent civil engineer be appointed member or chairman of the Board of Public Works and given a salary of $5,000 a year and required to devote all of his time to the Board of Public Works. We would also recommend that the salary of the Chief Engineer be raised to $5,000. Both of these suggestions can be carried out without any modifications in the present city charter.

The Louisville Board of Public Works consists of three members, as follows: Messrs. Alex. G. Barret, Chairman, John H. Brand and Charles C. Stoll.

The Slide in the Necaxa Hydraulic-Fill Dam.

On the morning of May 20, 1909, 550,000 cu. meters (715,000 cu. yds.) of the up-stream portion of the great Necaxa hydraulic-fill dam, under construction in Mexico, slid into the reservoir which was being framed above it. Two days later, Mr. James D. Schuyler, M. Am. Soc.

FIG. 1. VIEW OF DOWN-STREAM SLOPE OF THE NECAXA DAM BEFORE FAILURE, SHOWING HAND-LAID FACE AND WEEP HOLES.

C. E., Consulting Engineer of the dam, started from Los Angeles for the scene of the disaster. There Mr. Schuyler met Dr. F. S. Pearson, M. Am. Soc. C. E., Vice-President and Consulting Engineer of the Mexican Light & Power Co., which is building this and three other hydraulic-fill dams about a hundred miles from the City of Mexico, to supply electric light and power to that city and vicinity.* Mr. Schuyler has very kindly responded to our request for information regarding the failure, which we give below.

The following notes on the design of the dam and its failure were taken from a letter to this journal, written by Mr. Schuyler on June 12, the day of his return from the dam.

Notes on the Failure of the Necaxa Dam.

By JAM. D. SCHUYLER, M. Am. Soc. C. E.

The extreme height of the dam as planned was to be 59 meters [about 190 ft.]. The width on top was to be 16½ m. [54 ft.]; the up-stream slope 3 on 1, and the down-stream slope 2 on 1. The materials which were available for the construction of the dam when first planned were apparently of great abundance on the north end, consisting of yellow clay and broken limestone, mixed in about equal proportions. The design of the dam called for the central third to be composed of clay, with the fragmentary limestone resting upon it, the largest pieces being placed upon the outer slopes, grading in size to the smallest particles in the interior. The dam had a total estimated content of 1,639,690 cu. m. [2,130,000 cu. yds.], of which 1,474,000 cu. m. [1,926,000 cu. yds] were in position at the time of the accident. The rock on the slopes settled very firmly into position, and apparently was draining the interior clay core in a very satisfactory manner, although we were able to push down 1-in. pipes by exerting the force of six men, to a depth of 50 or 60 ft. This soft area was confined to the center, the clay on the sides being well solidified where it was drained by the rock fill on the slopes.

Prior to the accident, owing to the extreme drought, the storage of water in the reservoir had been exhausted, removing the pressure from the up-stream side, and at the same time the rapidity with which the work was progressing resulted in raising the pond on top of the dam very rapidly. The accident was in the nature of a slip of the soft material into the reservoir by lateral pressure, pressing out the up-stream slope at a point where material of less specific gravity than the limestone had been employed. The volume of material which was pushed out spread over the reservoir floor for a distance of some 200 m. [650 ft.] up-stream from the dam, and measures approximately 555,000 cu. m. [720,000 cu. yds.]. The down-stream half or section of the dam was left intact with its covering of masonry, while the clay filling against it was left standing at quite a sharp angle. The break occurred at an elevation of about 15 m. [50 ft.] from the lowest bottom, and over the greater portion of the core of the dam there is a depth of at least 25 m. [80 ft.] of compact and fairly solid clay. The sides of the canyon against which the dam was resting were covered with a heavy blanket of clay of the finest quality which had solidified in a most satisfactory manner.

The gap in the up-stream slope is about 120 m. [390 ft.], or one-third of the length of the dam. The remaining portion is chiefly composed of limestone, which has been undisturbed. It is apparent that the strain to which the slopes of the dam were subjected was much greater from the pressure of the pond on top than it could ever be subsequently with water in the reservoir to a corresponding height, and that with the entire core material solidified to the extent that the outer portions were found to be where the drainage was perfect, the stability of the structure could have been unquestioned.

A sample of the core was taken from the interior of the crater as it was left after the slide, where it was clinging to the side of the down-stream slope almost vertically, to a thickness of 8 or 10 ft. This sample was moist, but firm and dense. In its moist state the specific gravity was 1.753. The specific gravity of two samples of the limestone was determined at 3.400 and 3.370, which is remarkably heavy.

The entire slide occurred within the space of about one minute, and fortunately it happened at 6.05 a. m., before the day shift had come to work. There might have been several hundred men on the dam at the time had the accident taken place an hour later. Eighteen peons and three American foremen constituted the sluicing force at the time. These men were all on the flume on the upper toe at the time, and with the exception of two Americans they were all carried out with the slide some 200 meters or more before the material came to rest. Four peons were drowned, and the remainder escaped injury.

At the rate the work was progressing the dam would have been completed by the middle of July. It will now be finished to a height of 1 m. [3.28 ft.] above where it was at the time of the break and then allowed to settle for several months before completion. A spillway will be

FIG. 2. VIEW OF NECAXA DAM FROM A POINT NEAR INLET TOWER, SHOWING UP-STREAM FACE.

*Brief descriptions of these dams were given by Mr. Schuyler in a lengthy paper on "Recent Practice in Hydraulic-Fill Dam Construction," presented to the American Society of Civil Engineers, Dec. 16, 1906. (See Trans. Am. Soc. C. E., Vol. LVIII., p. 240.)

excavated at a level five meters below the temporary crest. Some six or eight months' time will be required to restore the dam to the condition which it was before the slide. In making repairs the up-stream toe will be restored with rock having an inner slope toward the center and resting upon its own base instead of reclining upon the clay core, and the clay core will be reduced to a minimum. Fortunately the down-stream toe of the dam is of such excellent quality that it can be used for the storage of water during the current rainy season, and reconstruction can proceed without interruption of service to the power-house and the reservoir can be filled to a very considerable depth without interference with the work.

The management and all the engineers concerned are satisfied with the hydraulic process of dam building, and are going to proceed not only with this dam but with several others under construction with the modification of the retaining fills on either side being self-sustaining. Had the dam yielded to water pressure from the reservoir, it would have spelled failure to the system, but no such thing occurred.

bankment of clay, having theoretical side slopes of 1 to 1. The base width of the embankments of materials composed of rock, or rock and sand, was about 350 ft. on the up-stream side and 250 ft. on the down-stream side, while the central core has a base width [as originally designed] of about 365 ft.

The theory upon which this design was made was that as the rock embankments advanced in height and rested upon the clay they would aid in forcing the water out of the clay by the superimposed weight, so that the portion of the clay underlying the overhanging part of the rock-fill at least would become particularly hard, while in the center the water would be forced to rise as the weight of clay increased, and that section would also finally become hard somewhat later. It was always recognized that we had a great excess in thickness of clay in the center core, but as the materials in the pits where broken stone and clay were mingled were found in about equal proportions it was not regarded as detrimental to have a layer of clay of extraordinary thickness. We did not want to waste the excess of clay, and so it went in. Could we have known that this particular clay is extremely slow in maturing or parting with its water when in a mass like this, and remains semi-liquid far longer than most clays of the North, such for instance as result from the decomposition of granite, we could have applied the remedy by reducing its width at base and increasing the

FIG. 3. VIEW OF NECAXA DAM AFTER SLIDE.

(Note how the soft core of the dam between the rock fill slopes has sloughed out for some distance back of the original break in the upper slope.)

The following extracts from my official report on the slide, dated June 3, 1909, take up the conditions and the cause of the slide in more detail than do the foregoing notes:

The accident is quite unique in the building of such dams, and being without precedent the lesson it conveys is all the more profound and impressive.

The first question invariably asked in cases of this sort is what caused the accident, and who or what agencies are responsible. As I recommended the type of dam, designed its dimensions and method of construction, and have supervised it from time to time since it began, it is natural that I should be looked to for a plausible explanation of the reasons for the occurrence, not only in vindication of my own position as an exponent of a system of construction which is somewhat in its infancy, and not as yet fully standardized, but to convince the company and the world at large who have been watching this work with intense interest that neither the system of construction nor the design was at fault.

As far as the type of dam is concerned, and the system by which it is built, there can be no question of its superiority over all other methods of construction where the materials available for construction consist of solid rock in place and clay or a mixture of broken stone and clay. For economy of handling, conveying, separating, depositing and consolidating such materials no system can compare with the hydraulic method. It is admitted without argument that the system was particularly well adapted to the situation at Necaxa. The design of the dam was such as to give two embankments of porous materials resting upon a central em-

width of the retaining dikes of rock. The difference in behavior between this clay and all other clays with which I have built dams is very marked, and is largely responsible for the lack of stability in the design adopted. It would have required longer time to put in rock in the place of any considerable portion of the clay core, and as the clay would have been wasted the cost would have been much greater. Some regard for economy, therefore, influenced the design admitting of so much clay. To illustrate the difference in clays I may cite a few examples:

The Lake Frances dam, in California, built wholly by sluicing, was composed almost entirely of clay, and while it hardened quite slowly, it solidified by its own gravity and natural side drainage, and became hard, solid and stable. The water in the reservoir was usually kept within 10 or 15 ft. of the top during construction. The rate at which the pond on the dam was raised was, however, less rapid than the rate of the past eight months at Necaxa, and possibly the clay had rather longer time to settle.

At the Santo Amaro dam, in Brazil, the materials used in sluicing were disintegrated granite, containing a reddish clay which contained considerable mica, which is usually a strong lubricant. The puddle core of this material became firm under water immediately after being deposited, and was really more stable and would stand up more firmly than the sand and gravel separated from it. A washout occurred which demonstrated the remarkable stability of this clay. In a shallow section of the dam (which is a mile in length altogether) the side levees had been built up by hauling in sand with cars. This material could not be so well settled as the sluiced material, and a break in one side occurred, washing out about 50 ft. of the levee as well as its base down vertically to the original ground surface, the summit pond being quickly emptied the entire length of the dam. Although the water fell vertically over the clay a height of some 8 or 10 meters [26 to 33 ft.] the freshly deposited puddle stood up, resisting erosion almost like stone. This was quite remarkable, as the oldest of the clay had not been deposited more than three months.

The fine surface soils of the plains of Idaho, which geologists say are wind-borne, resemble clay in appearance, but the dams I have built of this material drained out so quickly that one could safely walk over the pond of the hydraulic-fill a few hours after the water had been drawn off the top.

I cite these examples to illustrate the fact that Necaxa clay is different in its behavior under water from the great majority of such materials found elsewhere.

We were not careless or indifferent, or lacking in investigation as to what the clay in the dam was doing, for on almost every visit I had soundings made to learn its condition, and it was always reported as becoming firm at a depth below 4 or 5 meters [13 to 16 ft.] from the top. Finally, in January I suggested a device for bringing up samples at any depth desired, and urged that tests be made over the puddle-core to determine its nature. This device was made and the samples were taken and reported upon in March. They showed a softer condition than was anticipated, and it was found to be possible to force the 1-in. pipe down practically to the bottom with four men. Still, the clay brought up was stiff and contained but little more moisture than the ordinary clay soils in a bank of that material. It certainly appeared firm enough to resist transmission of hydrostatic pressure laterally for at least half its depth from the bottom up.

Since the break we find by examining the sides of the emptied puddle core that there is left clinging to these sides a very considerable thickness, say 2 to 5 meters [6 to 16 ft.] of clay which had parted from its surplus water by drainage into the adjacent rocky embankment, or into the tepetate of the hill sides, and became solid, stable and firm, as we expected it all to become.

A test pit was sunk June 1 in the lower toe embankment, in a bight where the 1,310 contour is furthest from the center line, to find out what the material was like in that location. This pit went down 2.40 meters [7½ ft.] through stiff yellow clay, in very firm condition, containing particles of gravel in places. From the bottom of this pit a sounding rod was churned down to a further depth of 2.30 m., by eight men, passing through practically the same class of material. They stopped at Elev. 1305.30 as they could get no further.

Nothing could be more satisfactory than this. In fact the entire down-stream toe embankment was built up at all times under more favorable conditions, with a broader crest, and greater superelevation above the pond than the up-stream toe dike. This was due to the position of the dam being so located as to lap over the face of the hills on each side, in order that the latter could be covered with a blanket of clay to prevent leakage from the reservoir through the tepetate. This made the up-stream toe much longer than the down-stream toe and consequently it required much longer flumes to carry materials.

In order to have the progress of the up-stream toe keep pace with the other the crest was always made narrower than the broad top of the down-stream toe, while theoretically it should have been wider. To increase the pace on this slower side of the dam it was finally resolved to go to the south side and begin sluicing from the clay and tepetate on that side. I consented to this with reluctance, as I had always endeavored to avoid the use of tepetate or the reddish clay that goes with it, and in my original report recommended that the dam be built exclusively of limestone and the yellow clay accompanying it.

The down-stream toe doubtless owes its superior stability to the fact that limestone has been used in its construction exclusively up to about Elev. 1325. Having a slope of 2 to 1 it was theoretically less stable than the up-stream slope, built 3 to 1, but the limestone weighs practically twice as much as the tepetate, and as the part of the up-stream slope where the break occurred was entirely composed of tepetate except possibly for 3 or 4 meters in the bottom, if my recollection serves me, it was less stable than the down-stream toe, even though of greater bulk as planned. Actually there were narrow places in the crest of the up-stream toe, very frequently, due to the fact that the flumes did not always quite meet from each side.

In a photograph taken March 31, 1908, one of these narrow spots is shown directly on the line of the 10-ft. pipe where the slide started. In such a bay left by a narrow crest, clay would be deposited away outside the theoretical section. This was the spot where a break occurred March 2, 1908, when the summit pond was emptied and some 10,000 cu. m. of clay were washed into the reservoir. It is quite evident that this old break and the fact that the crest of the up-stream toe was not im-

mediately refilled to the full width, were contributing causes of the accident.

It has been suggested that possibly the heavy blasting which has been done for many months past might have been another contributing cause, as they frequently shake the ground very sharply, and such shakes might have opened a way for water to percolate from the summit pond out underneath sufficiently to lubricate the mass. This suggestion might have some weight had there been heavy blasting immediately prior to the slide, but I understand there was not.

Summarizing my views as to the cause of the accident, I think the disaster was due to a combination of four principal conditions or facts, as follows:

(1) The scarcity of water due to the long drouth and the subsequent emptying of the reservoir, for had the reservoir been half full, as it would have been under normal conditions, the pressure on the up-stream slope, in combination with the gravity of the stone itself in that slope, would have counteracted the hydrostatic pressure of the summit pond, and the equilibrium of the mass would have not been disturbed. Once the pond on top was replaced with earth or rock the drainage of the core would have proceeded more rapidly and the mass have become solidified within a few months thereafter.

(2) The peculiar quality of the clay, which did not harden in the center, although making both side embankments impervious to water. In this respect it differed from other clays that have been used for this type of dam elsewhere.

(3) The narrow crest width of the up-stream rock-filling, due to the greater length of that side, and the constant difficulty of keeping the flumes built sufficiently in advance of the work.

(4) The use of tepetate, having a specific gravity of 1.75 to 1.80, for the up-stream rock-fill in place of limestone with a specific gravity of 3.0 to 3.4. This, combined with the particularly narrow crest width which existed at the time of the break of March 2, 1908, where much clay must have been deposited dangerously near the edge, and directly in line of the final break, might have been the most important of all the contributory causes.

FIG. 4. VIEW OF NECAXA DAM AFTER SLIDE, SHOWING MATERIAL WHICH SLID INTO RESERVOIR.

REINFORCED-CONCRETE WAREHOUSES ALONG the Seine between the Pont d'Austerlitz and the Pont de Bercy have recently been built and are very completely described and illustrated in Le Génie Civil, June 21, 1909, p. 162. The houses, which are really one three-story building, 1,575 ft. along the banks of the river and 131 ft. wide and divided into 12 separate buildings, are the first to be built along the Seine for the joint loading and storing of goods. They are constructed after the standard beam, girder and column type of reinforced concrete and carry on each of the three floors and on the roof electric cranes which travel on tracks parallel to the river. Loading and unloading is carried on by these cranes which are supplied from minor cranes running on the transverse beams.

The Status of the Civil Engineer's Profession in the United States.*

By ONWARD BATES, President, Am. Soc. C. E.

Engineers have long desired a concise and sufficient definition of the profession, and failing to obtain one that is satisfactory, have usually fallen back on the old one, attributed to Thomas Tredgold, as it is given in the charter of the Institution of Civil Engineers, dated June 3, 1828, which is as follows:

> The profession of a civil engineer, being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and light-houses, and in the art of navigation by artificial power for the purpose of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns.

In the 81 years since the incorporation of the British institution, no better definition than the one given by Tredgold has been submitted, and perhaps no better definition could have been offered. It was thoroughly comprehensive of the duties of an engineer in the state of civilization at that period. Since then, in the unparalleled progress of civilization, his duties have been enlarged, diversified, and multiplied, until it seems impossible to state in words what may reasonably be expected of a civil engineer at the present time.

Engineers are made, not born. They are pre-eminently "self-made men," the product of their own works, men producing experience and experience making men. The engineer has always been a worker, living for others rather than for himself. His mind has been fixed on professional achievement without regard to personal advancement. He has shown himself to be the greatest source of power in nature, and his reward has been mainly in the accomplishment of good for his fellow-men. The community has not even returned to him the equivalent for what he has given.

Engineers may be justly proud of their calling, and yet it must be recognized that, professionally, they are not well established, either among themselves or in their relations to the public, and that the status of the profession at the present time is not such as they should be satisfied to rest upon.

An analysis has been made from the list of members of this society dated February, 1909, showing what each of the 2,380 members has stated to be his occupation. In selecting this limited number, no reflection is intended on the associate members, nor on the qualified engineers of this country who are not connected with the society. It is considered that the members furnish a sufficient number of representative engineers for a basis of investigation, and that no better list of experienced civil engineers can be obtained, since admission to the grade of member is a certificate of professional attainments and experience, and it is doubtless, also, a fact that, the majority of the engineers of America who are qualified for the grade of member, are already enrolled as such. The distribution of this list of members with regard to their occupation, as stated by themselves, is as follows:

U. S. Government Service:			
Army Officers	41		
United States Assistant Engineers, etc.	61		
Navy	25		
Reclamation Service	29		
Geological Survey	7		
Coast and Geodetic Survey	4		
Panama Canal (exclusive of army officers)	7		
Miscellaneous	10		
		184	7.7%
State and Municipal Public Service:			
State Engineers	7		
City Engineers	50		
Water Supply	60		
Sewerage	16		
Streets and Highways	13		
Rivers, Harbors and Canals	36		
Wharves, Docks and Ferries	8		
Bridges	20		
Miscellaneous	91		
		301	12.7%
Railway Service (including traction lines):			
Executive Officers	30		
General Managers	20		
Chief Engineers	99		
Miscellaneous	212		
		361	15.2%
Manufacturing Contracting, etc.:			
Bridge and Structural Steel Cos.	85		
Light and Power Companies	48		
Contracting	156		
Manufacturing and Supplies	129		
		418	17.6%
Consulting Engineers:			
Civil, Mechanical, Electrical Sanitary, Hydraulic and Mining	482		
		482	20.2%
Other Specialties:			
Architects	21		
Professors and Instructors	82		
Editors	6		
Miscellaneous	14		
		123	5.1%
Unclassified	511	511	21.5%
		2,380	100.0%

From this analysis it is not possible to classify members on the basis of qualifications, but a fair idea of the nature of their employment may be obtained. It is to be observed that 20% of the members are in the service of the government, either national or local; 15% are employed on railways; 18% are engaged in manufacturing or contracting operations; 20% are consulting engineers; 5% consist of architects, professors, etc.; and 21% are unclassified.

Many of the members included in this list are also members of the national societies of mechanical, electrical and mining engineers, who, if restricted to one society, might not elect to be classed among the civil engineers. The large number appearing as unclassified consists of those whose names appear in the list of members with their addresses given, but whose occupation is not stated. Many of these are engaged as consulting engineers; some were perhaps out of employment when the list was made; some have retired from active work; and others, for reasons of their own, have simply listed their addresses. It is in the nature of the civil engineer's occupation to have frequent changes of residence and of employment, and the list only holds good for the particular time at which it was made.

Assuming that engineers in public and railway service, and those engaged in manufacturing, etc., are salaried employees, this general class will be in the majority, the exact proportion being impossible of determination. It is also a safe assumption that, for associate members and juniors, and civil engineers who are not members in any grade of the society, the proportion of salaried engineers throughout the country is much greater than in the grade of members. It is, therefore, a reasonable inference for the profession at large, that at least three-quarters of those who have employment are engaged for salaries, and that less than one-fourth of them depend on fees for their income.

No attempt is made to classify this list with respect to rank or income. Neither the title of the engineer, nor the class of employment, indicates the importance of his work. A chief engineer in the railway service may be in charge of 10,000 miles or of 100 miles of line, and in some instances may be vested with executive and administrative power, while in other cases this power is reserved to his employers, and he simply works under instructions. This illustration from the railway service applies to a greater or less degree throughout the list. Outside of the government service, there is no common understanding of the duties, responsibilities, and remuneration attached to any given title for an engineer. All these appear to be fixed by the employers, and to be dependent on their personal appreciation of the man and his work.

With the natural desire of employers to get as much as they can, and give in return as little as they must, there is a well-grounded belief that the average pay of the engineer is less than it should be for the services ren-

*Abstracted from the Presidential Address at the 41st Annual Convention of the American Society of Civil Engineers at Bretton Woods, N. H., July 6.

dered by him. Under these conditions, engineers are reticent as to their salaries and fees, and, for the purpose of studying their relation to the profession, there is no way of ascertaining what these amount to. It is an unfortunate condition that the rank and value of positions held by engineers are not more definitely fixed, and it may be taken as an indication that the engineer's status is not rightly determined. If this conclusion can be drawn from an examination of the list of members of the society, it will apply with more force to a consideration of the much larger number of the engineers of this country who are not included in that list.

Civil engineers are human, and need food and clothing and shelter in common with all mankind, and yet their subsistence is precarious. As a class, they are scattered over the country, frequently isolated from their fellow-men, and with employment of a temporary nature. They do not generally become identified with local interests, being employed to do special work, and dismissed when that work is completed. Thus the engineer is a means to an end for other people, who employ his services for a remuneration, which is frequently less than their actual value, and who terminate his employment as soon as they feel they can get on without his aid. He is even sometimes classed by his employers as a necessary evil. He is considered an alien in the community, is uncertain regarding permanency of employment, and in consequence is not so capable of making plans for a domestic life as he would be if engaged in some other occupation.

The status of the profession, and the condition of its members, is better than in any former period, and yet neither is what it ought to be and will be, if engineers do their duty. The profession cannot be considered apart from its individual members. That which raises or lowers individual standards will have a corresponding effect on the profession, and any improvement must result from the work of its practitioners. It is incumbent on all engineers to engage in individual and combined efforts for the advancement of the profession, to the end that greater efficiency may be promoted, that the public may be educated into a better knowledge of what it offers, and that rewards which are more commensurate with achievement may be secured.

Let the engineer, in examining his own condition, apply the methods which he would use if engaged to report on an engineering work, and he will search for the weak points as well as for the elements of strength. His training and practice have taught him to regard himself as separated from his fellow-men, with the result that he becomes the tool of those whose aim is to control men and to profit by their knowledge. The end is that he is a servant where he should be a master. Herein lies the weak point in the profession—may I be pardoned for naming it professional narrowness, while I try to point the way to convert weakness into strength. It is necessary for the engineer to be more of a "mixer" than he has been, and to assume the initiative in many cases in which under similar conditions he has been a follower. He should be a manager, and should give orders to others who can do the work under his direction as well as he himself could do it with the situation reversed. It should not be considered unprofessional for an engineer to be a capitalist, and, when he takes his proper place as promoter and organizer and shares in the profits of engineering enterprise, he will no longer be taunted with the saying, that "an engineer is only good to spend other people's money." It is by acquiring individual strength that the engineer can give strength to the profession.

It is well known that engineers of admitted proficiency often have to work under the direction of men who are unfitted by education and experience to direct engineering work. This is because the engineer is a workman while the other party belongs to the class of "managers." The engineer has not reached his proper rank until he can hold the position of manager, as well as that of a designer and supervisor of work. A better position will be secured whenever the engineer makes it his business to study men as well as materials, and to use men as he does machinery. The advancement must be individual, by fitting one's self for managing duties, assuming those duties, and "making good" in their performance. There is no room in the profession for trades unionism, for by its very nature the profession lives on competition, and its practice is a race for higher things. Let there be no mistake, however, in construing these higher things. Professional success is not wholly in building public works, or obtaining fame as a designer or director, or in the accumulation of money—all of which are worthy ends—for it includes making the name of the profession honorable, and the promotion of the welfare and happiness of its members; and these separate objects are not inconsistent or conflicting with each other.

The same conditions and circumstances which tend to limit the advancement of the engineer as an individual have the tendency of limiting the profession as a whole. Segregation and isolation stand in the way of combination for mutual and joint interests. While trades unions, as they are commonly understood to exist, are not to be desired in the profession, the engineering societies offer the best means of united effort for its advancement.

The American Society of Civil Engineers is the representative national society. Its objects are "the advancement of engineering knowledge and practice and the maintenance of a high professional standard among its members.". The acceptance of membership by an engineer is a practical pledge to work for the high objects for which the society was organized. How these objects may be attained should be the subject of anxious care by all members. University degrees are honorable, but they only certify that the possessor is prepared to enter the practice of his profession, and are not indicative of his accomplishments in it. Membership in local engineering societies is creditable, but usually the standards for membership in these societies are not as high as in the national society, and it is not unusual for men of prominence in the profession to hold membership in both the local and the national society. The local societies are not rivals of the national society, there is need for each, and they have a common purpose which should guide them in harmonious cooperation for the good of the profession.

The society is under obligation to its members to advertise in all proper ways the advantages of employing them. Our national and local government officials, private corporations, and individuals, who require the services of engineers, should be made aware of the fact that one cannot be a member of the society in any grade until his personal character, his professional knowledge and his practical experience have all been investigated by a board of thirty of the older men in the profession, who are charged with the duty of admitting into the society only such as are proven to be worthy and competent. The society cannot become an employment agency, nor can it recommend individuals, or discriminate in any manner among its members, but its membership list should be a reference book for the employing public. Membership in the society at the present time is a recommendation to employers, and has a money value to those who hold it, and this value will be greatly increased in the near future, as the profession is expanded by the increasing annual additions to it.

Owing to the incoherence of the profession, it has no established code of ethics, and the influence of the society should be exerted in this direction. The necessity of a code is not so apparent among civil engineers as elsewhere, for the reason that it is in the nature of the profession to abhor all that tends to fraud or quackery. Still, a code must exist, even if it is an unwritten one, and the diversity of professional employment is such that nice questions may arise between engineers, or between them and their employers or clients, which may lead them into error. The society is perhaps not in a position to formulate and recommend such a code, and yet it can do much to establish the right relations between its members. It can, through the influence of its members, exercise a wise restraint on unprofessional tactics.

Members acting in their individual capacity may create a sentiment in the profession and among employers for equitable remuneration of the engineer's services. Engineers in administrative positions may stand for fair salaries and professional consideration for those in subordinate positions. Consulting engineers may educate their clients to a reasonable knowledge of the value of advice, and, by their conduct, may exhibit the distinction between such as are entitled to be termed consulting engineers and those who assume the title without the knowledge and experience to qualify them for it.

One of the weak spots in the profession is the lack of a standard of capacity. It should be the case that an engineer's rating of competency is established by the opinions of his fellow-engineers, whose duty it is to recognize his merits and class him accordingly. For this reason, engineers should seek to enlarge their acquaintance in the profession, and should desire the honor and responsibility of membership in the society.

THE WORLD'S SHIPBUILDING.—The following figures are published in the (London) "Iron and Coal Trades Review" of July 21 showing tonnage of boats launched. Some of the 1908 figures are only approximate and to the totals of both years must be added the comparatively insignificant tonnage of such countries as China, Greece and Spain, amounting to a possible 120,000 tons:

	1907. Tons.	1908. Tons.
United Kingdom	1,828,800	1,077,000
Germany	323,900	327,400
United States	455,700	320,350
Holland	145,000	153,500
France	113,300	104,350
Japan	127,750	79,260
Norway	52,400	46,520
Italy	85,380	44,000
British Colonies	30,400	30,500
Austria-Hungary	42,000	27,000
Belgium	17,700	22,500
Denmark	27,350	19,080
Sweden	15,100	11,000
Russia	28,700	700
	3,292,980	2,263,160

The Status of the Civil Engineer in Great Britain.*

By JAS. C. INGLIS, President Inst. C. E.

The movement to secure definitely the better education of engineers, which was initiated in 1889, has developed into a system of examination on a large scale; and although here there may be room for differences of opinion, yet, on the whole, the fact cannot be controverted that the examinations for the admission of students to the institution and to test the scientific qualification for election to associate membership, are of a high order, and are widely recognized as standards of general education and technical knowledge.

The test of practical attainments is, perhaps, a more difficult matter to deal with, and the mode of acquisition of such attainments, as you all know, has undergone and is undergoing a great change, arising from the altered position of pupilage in the engineering and allied professions generally. Undoubtedly further expedients and efforts will have to be made by the institution to secure a standard of test for practical knowledge as satisfactory and definite as that which now obtains for technical and scientific knowledge. In addition to the candidates who have qualified by the examinations of the institution a large number have qualified by means of other examinations; and it is a cause for satisfaction that while the institution has so firmly established its own examinations, it has broadened the basis of qualification by recognizing as exempting therefrom, examinations of all British universities and colleges which comply with the requirements that have been laid down by the examinations committee of the council.

The process of strengthening the profession by protecting the entrance to it is necessarily the first great operation in improving the general status of the engineer; and naturally following, while to some extent concurrent with it, is the further necessity of regulating the business involved in the practice of the profession of a civil engineer. Of course, in approaching questions which relate to the personal and individual interests of the members, it has to be borne in mind that such interests must be always subservient to the particular objects for which the institution was founded and received its royal charters. Our primary object is to make the institution strong and efficient in the promotion and dissemination of engineering knowledge, and thereby to advance the status of engineering as a profession. It cannot be gainsaid, however, that when a body becomes so numerous and so diverse in its activities as our own, questions are involved in the promotion of its professional status which concern its members personally, and apart from their support of the institution as a scientific organization. The subject has received a large amount of attention from the council, but chiefly on account of the transition period through which, I do not hesitate to say, the profession has been passing, difficulties have been encountered which have prevented the full exercise of such discipline as a great body like the Institution of Civil Engineers should possess: but I venture to hope that having done so much to secure the proper training of its new members, there must assuredly be subsequent attention given to the control of the practice of civil engineering.

I may allude to a fact, possibly known to many, that several important departments of state rely to a considerable extent upon the work of the council of the institution, and in some cases upon advice given by it, with respect to questions of the qualification of engineers and of their selection for public services. The result of all this strengthening of the efficiency of the institution is that a higher average technical proficiency is undoubtedly attained by the young engineers attached to it than was formerly the case, and this state of affairs has been notably marked by the action of the India Office with respect to engineering appointments in the Public Works Department; and very recently by the War Office, which has entrusted to the council of the institution the important function of selecting and recommending young engineers for nominations to the newly-organized Reserve of Officers for the Royal Engineers.

The engineering profession is, as I have said, like most commercial interests, passing through a period of rapid development and change, and from its very nature must be more susceptible to changes than its fellow professions of the law, medicine, etc. I do not contend that membership of this institution is the only criterion of engineering competence, but if the India Office and other great departments of the state are alive to the desirability of public moneys applied by these well-organized departments to engineering purposes being administered by definitely qualified engineers, I hope it will not be considered as going too far to suggest that in this year 1908, it ought to be laid down as a principle that all public money derived from rates and taxes should be, so far as it is applied in engineering construction, expended under the direction or control of

*Extracts from the Presidential Address before the Institution of Civil Engineers, Nov. 3, 1908.

definitely qualified engineers, as is already the case in many countries.

The establishment of any such principle is clearly a matter for practical politicians and economists. The institution has ever aimed at justifying rather than inviting confidence in its members, and it may be assumed that this attitude represents the general sense of the engineering profession. Such a position as I have suggested would, however, be mutually advantageous to the public on one hand, and to the profession on the other. It would promote efficiency and economy in much public expenditure, and would immensely strengthen the practical side of the profession in Great Britain; and, by strengthening the body of engineers, from whose ranks must be drawn many of those who have to serve the needs of the Empire and British interests all over the world, would equally benefit the state.

Another, and somewhat consoling consideration, I would venture to place before you, and then I have done. The ideals of nations are different, as we all know, but I was hardly prepared for so precise a statement on the British and German ideals as that made recently by an eminent German professor lecturing on economic subjects. He said:

> The aim of the German was everywhere to leave as little as possible to chance in the great struggle of the twentieth century, not to allow people to muddle through somehow, but to eliminate as far as possible the element of the unforeseen, while carefully training the mind to cope if necessary in an intelligent way with any emergency. While the British had, as a rule, a violent suspicion of the expert, and a strong belief in the untrained unpaid amateur as the right source of wisdom, allowing the expert to advise and the amateur to decide, the German had no fear of the expert. He well saw the possible danger of red-tapeism at the hands of highly-trained officials, but he found them less than the dangers arising from the decisions of well-meaning but untrained and inexperienced amateurs.

If these principles were more acted upon in this country, as in time they must be, I think you will all agree with me that many members of this institution would find increased scope for their energies, and added interest in the engineering problems they have to deal with, while, without doubt, better results would, on the whole, ensue for capital.

Gold Output of the Transvaal.

The accompanying table and diagram, reproduced from the annual report of the Government Mining Engineer, Transvaal Mines Department, for the year ended June 30, 1908, shows the great increase in the world's production in the last 20 years and the large part which the Transvaal has played in that increase.

In 1888, when the gold output of the Transvaal first attained some importance, it amounted to about 4½% of the world's total output. Since then it steadily increased up to the Boer War, amounting, in 1898, to more than 27% of the world's total. During this period preceding the war, although the combined production of the rest of the world's mines was steadily advancing, the output of the Transvaal showed a higher rate of increase so that, except for a slight fluctuation in 1895 and '96 due, perhaps, to the influence of the Alaska-Yukon production, it constituted each year a continually greater per cent. of the total.

During the war (October, 1899 to May, 1902,) the output dropped to about 2% of the world's total, and was in 1901 about the same by weight as in 1888; but the recovery following the termination of the war was prompt and rapid. The production in 1904 surpassed that for 1898, marking the complete recovery from the effects of the war, and it has since resumed approximately its former rate of relative increase, until it amounts in the statistical year 1907 to nearly 33% of the world's total production.

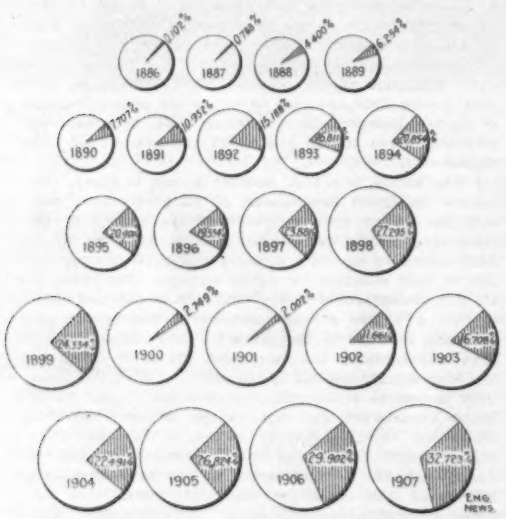
The world's average yearly gold production during the period 1841-50, according to a table published in "A Treatise on Gold and Silver," by Walter R. Crane, M. Am. Inst. M. E., was 1,760,000 ozs. (54,759 kg.). Due to the rapid development of the California gold fields, the production for 1851 was about 3,441,000 ozs.—nearly double the amount just given—but in 1856 it had again doubled, being for that year 7,140,000 ozs. This was a maximum not again approached until 1892, when, according to the table in Mr. Crane's treatise, the world's production was 7,075,000 ozs., a figure which agrees fairly well with the estimate given in the present table.

The world's annual gold production has quadrupled since 1884 and has more than doubled since 1895; the output of the Transvaal was insignificant in 1884 and has more than trebled since 1895. In 1907 the Transvaal's output was greater than the total for all mines in 1891 or any previous year except 1856 and '57.

GOLD OUTPUT OF THE TRANSVAAL COMPARED WITH THE REST OF THE WORLD.

Year.	World. Fine Ozs. (estimated)	Transvaal. Fine Ozs.	Transvaal. £ Stg.
1884	4,950,000	2,376	10,096
1885	5,050,000	1,414	6,010
1886	5,044,000	8,171	34,710
1887	5,061,000	39,880	160,401
1888	5,176,000	227,749	967,416
1889	5,611,000	350,909	1,490,568
1890	5,711,000	440,152	1,869,645
1891	6,286,000	688,439	2,924,305
1892	7,039,000	1,069,058	4,541,071
1893	7,675,000	1,290,218	5,480,498
1894	8,656,000	1,805,000	7,667,152
1895	9,652,000	2,017,443	8,569,555
1896	10,359,000	2,025,510	8,603,821
1897	11,488,000	2,743,518	11,653,725
1898	14,008,000	3,823,307	16,240,630
1899	14,949,000	3,637,713	15,452,025
1900	12,687,000	348,761	1,481,442
1901	12,889,000	258,032	1,096,051
1902	14,741,000	1,718,921	7,301,501
1903	15,891,000	2,972,807	12,628,057
1904	16,778,000	3,773,517	16,028,883
1905	18,303,000	4,949,541	20,854,440
1906	19,373,000	5,792,823	24,606,336
1907	19,713,000	6,450,740	27,400,992

Note.—October, 1899, to May, 1902, War Period.



Gold Output of the Transvaal Graphically Compared with That of the World.
(Period of Boer War, October, 1899, to May, 1902.)

The Boston Charter Amendments.

The charter legislation for Boston recommended by the Finance Commission, as noted at some length and commented on editorially in our issue of March 25, 1909, has been enacted by the Legislature, with some omissions, changes and additions. The act was approved on June 11. Portions of it became effective at once and other parts will go into effect at varying intervals between then and February, 1910.

It appears that the most important of the recommendations made by the Finance Commission have been enacted by the Legislature, except that there will be a referendum vote on an alternative to the Finance Commission's plan for the number of members in the city council, the term of office of the mayor, and methods of selecting candidates for councilmen and mayor. The Commission recommended that the term of the mayor should be four years, subject to a modified form of recall at the end of two years. The Commission also recommended that the city council should consist of nine members only, and that all nominations should be by petition, without party designations on the ballot. The Legislature inserted as an alternative to be voted upon, that the term of the mayor be two years, that the city council consist of 36 members, and that ward candidates be selected by primaries and candidates at large be chosen by conventions composed of delegates elected at the primaries. Of the 36 members under the alternative plan, 9 would be elected at large for three-year terms and the remainder would be elected by wards for two-year terms, with one for each ward, save that two of the larger wards would have two members each. The referendum vote will be taken on Nov. 2, 1909. Subsequently a mayor and members of the city council will be elected in accordance with whichever plan is adopted, and these officials will take office on Feb. 1, 1910. Other features of the charter amendments may be briefly summarized as follows:

The mayor is given absolute control over appointments and dismissals of officers holding administrative positions. The council is limited solely to legislative functions. The budget originates with the mayor and, while items of it may be decreased by the council, none may be increased.

The powers and duties of the city auditor are clearly defined, and he is given power to prescribe all forms of accounts. All bids for contracts must be made in duplicate and one of the duplicate bids must be delivered to the auditor. The auditor must hold unopened all the duplicate bids received by him until the other set of duplicate bids has been opened and read. In case any of the duplicate bids held by the auditor are lower than those in the other set, they shall be substituted.

All heads of departments, as has been stated, are to be appointed by the mayor. They must be "recognized experts in such work as may devolve upon" them, or else they must be "persons specially fitted by education, training or experience to perform" those duties. The mayor must certify to one or the other of these facts in making appointments, and must add that the appointment is made "solely in the interest of the city." Before the appointments become effective they must go to the Civil Service Commission for investigation and certification as to the facts alleged.

A finance commission of five members, to be appointed by the governor, is provided for. The chairman of the commission is to be paid $5,000 a year and other members are to serve without pay. Provision for the salary of the chairman, and for at least $25,000 additional for the expenses of the commission, must be made in the appropriations each year. The commission is authorized to employ such experts and other assistants as it deems necessary. It will be the duty of the commission

> from time to time to investigate any and all matters relating to appropriations, loans, expenditures, accounts, and methods of administration affecting the city of Boston or the County of Suffolk, or any department thereof, that may appear to the commission to require investigation, and to report thereon from time to time to the Mayor, the City Council, the Governor, or the General Court. The commission shall make an annual report in January of each year to the General Court.

In addition, the mayor, city auditor or city treasurer may refer to the commission any claim against the city which seems to be of doubtful validity "or otherwise contrary to the city's interest." Pending the report of the commission on such a claim, payment shall be withheld.

Sinking funds for the payment of bonds will no longer be provided; instead, bonds will be payable in annual instalments. Any premiums received on bonds sold will be used to reduce the total bond issue.

A municipal paper known as "The City Record" is to be established. It will be published weekly or oftener under the direction of the mayor. In it all city advertisements will be published, together with other information relating to the city, proceedings of the city council and the school committee, and all communications from the mayor.

In taking land for public use, condemnation proceedings shall be had, unless a price can be agreed upon not more than 25% in excess of the average assessed valuation of the land during the previous three years.

THE MICA PRODUCED IN THE UNITED STATES during 1908 amounted to 972,964 lbs. of sheet mica and 2,417 short tons of scrap mica with a total value of $267,925. In 1907 the production of sheet mica was 1,060,182 lbs., of scrap mica 3,025 tons, and the total value was $392,111. The average price of sheet mica in the United States during 1908 was 24.1 cts. per lb. as compared with 33 cts. in 1907. North Carolina is the largest producer, supplying in 1908 509,234 lbs. of sheet mica and 1,308 short tons of scrap mica.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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The unfortunate manner in which many of our cities are handicapped by legislative restrictions of purely local matters is well illustrated by excerpts from a report of the Board of Public Works of Louisville, Ky., which we publish elsewhere in this issue. The charter of Louisville, it seems, prohibits the Board of Public Works from paying more than $1,500 a year to any employee except the chief engineer. Under this restriction, the Board says, "it is impossible to get an efficient engineering corps." Its further pertinent remarks on the subject may be found at the close of the article just mentioned. The Board urges the necessity of securing the legislative repeal of this provision. Can anyone give a single sound reason why a city of nearly 205,000 inhabitants (1900)—or, for that matter, a city of any other size—should be compelled to go to the legislature to get permission to pay any of its employees whatever is necessary to secure the best man for the position? How much longer will the cities of the United States tolerate such unwarranted legislative interference in local affairs? Perhaps it is unfair to the legislatures to imply that the blame rests on their shoulders. Doubtless they would quickly enough shift the responsibility where it belongs if cities insisted upon it and made plain the eminently sound reasons for doing so.

That they "do things differently" in Great Britain when a city or town engineer is to be chosen is well known to those who are familiar with just how this is commonly done in that country. The matter has been brought to our attention anew by the following note in a recent number of the London "Surveyor:"

> Mr. Leslie Roseveare was last week appointed from among 120 candidates borough engineer and surveyor of South Shields. Mr. Roseveare, after gaining twelve months' practical experience in engineering workshops, was articled for three years to Mr. Edward Sandeman, M. Inst. C. E., M. Inst. M. E., the then water engineer of Plymouth, and served two years as an assistant with him during the construction of the Burrator reservoir. Immediately after his articles he was appointed assistant water engineer at Torquay to prepare the Parliamentary plans for the purchase of the watersheds, and in 1898 became general, and subsequently chief, assistant to the borough engineer and surveyor of Plymouth, during a time when the expenditure on new works was extremely heavy. In 1904 he was appointed deputy in the assistant engineer's department of the Birmingham Corporation, being subsequently raised to chief of that department on the appointment of his predecessor to the city engineership of Alexandria. Mr. Roseveare is an associate member of the Institution of Civil Engineers and the Incorporated Association of Municipal and County Engineers—both by examination—and is also an associate member of the Institution of Mechanical Engineers.

The foregoing note gives some idea not only of the way a municipal engineer is chosen in Great Britain, but also of the kind of training many of them receive, and particularly of the fact that as a rule a good engineer there has always before him the possibility of mounting up step by step from one department position to another, and then from one town or city to another, until finally he finds himself at the head of the engineering department of one of the principal cities of the realm.

Similar opportunities for advancement from city to city are conspicuous by their absence in this country, owing to the common requirement, statutory or political, that appointees to municipal offices must be residents of the city which they are to serve. That they will become residents through the very fact of local service if brought in from elsewhere, does not seem to be taken into consideration. Where political considerations and reward for public service govern appointments, as they so generally do in this country, it is generally thought to be quite impracticable to go to another city for an engineer, since it would perhaps be difficult to make sure that a man of the right political complexion could be secured—or, if secured, that his politics would not change with his domicile. There are, fortunately, some instances where men for engineering and other technical positions have been secured from other cities than those they were to serve. These are comparatively rare, but there is some reason to believe that they will increase in number in the future.

The tests on the fire-resistive properties of various building materials made by the U. S. Geological Survey and reported briefly on another page of this issue are only a beginning of the extensive work projected by that branch of the government, but, incomplete though they are, they demonstrate some of the necessary qualifications of the material which will best stand up against a fierce and prolonged fire.

The conditions of heat and quenching in the tests are much more severe than in the ordinary conflagration, but the experience of a few large fires has shown that they are not too severe for what a good building material should stand. In the Parker Building fire in New York, it will be remembered, the molten metal found showed a temperature close to 2,000° F. in places, which for the short time it probably raged is certainly equalled by the continued 1,700° F. of the tests.

Aside from the surface spalling which can hardly be prevented and which causes no permanent defect to the structure of a building, it is evident from the tests that the principal danger to be expected from a fire is the failure of the structure of the material from expansion under heat and the subsequent contraction under sudden quenching. This failure is permanent and not only causes a total loss of the material itself but, when that material is used as a curtain wall as most fire-resistive stones, tiles and concretes are, its failure means the destruction by fire or water of the interior of the building. The low coefficient of expansion and the low coefficient of heat conduction which generally go together are then the desirable qualities in a fire-resistive material.

Briefly the results from the tests are as follows: all of the material showed serious injury on the face exposed to the fire and quenching; all of the cellular blocks with thin webs and facing, both in concrete and in tile, cracked across the thin webs; all of the artificially made solid blocks, either concrete or brick, stood up very well under the severe conditions; all of the natural stone block cracked and crumbled and practically failed in toto.

These results can be easily explained. A building block or unit to be reasonably safe under long continued fire must have two properties; a low coefficient of expansion in the material and a sufficient area to resist the stresses of expansion. Lacking either of the two it will fail. Clay and concrete both have low coefficients of expansion and are poor conductors of heat, so in the tests in the solid blocks, either concrete beams or clay brick with a large area transverse to the heated plane, the only damage done was on that plane where the high temperature caused a surface expansion resulting in spalling. On the contrary when either material was made up in cellular blocks the small cross-sections of the webs and faces were not sufficient to resist even the low expansion, and the blocks either cracked or fell apart.

The natural stone has a high heat conductivity. All of the temperature curves show that the backs of the stone walls were much hotter than in any of the other materials. With this high conductivity there was also a high coefficient of expansion with the result that the internal stresses in the natural stone blocks were much greater than even the large area could resist and they cracked and crumbled.

Unfortunately this does not solve the fireproofing problem. Fireproofing means generally the protection of an otherwise non fire-resistant material; this protection must necessarily be light and thin and therefore, regardless of its nature, subject to more danger through expansion than if it were thick. The problem, therefore, is to decide upon the proper thickness so that the area is just great enough to resist the expansion and this the limited number of tests have not solved. The experiments have shown, however, that solid clay brick or concrete make good curtain walls and that hollow tile or concrete block are dangerous articles to submit to the intense heat of a severe conflagration.

The ancient tale of the rural railway where the cowcatcher was placed at the rear of the train to prevent live stock from climbing on board is matched by the following story in the Aberdeen, Dakota "News":

> The Milwaukee passenger train left Lemmon for the East last night at 9.50, 40 minutes late. Some distance this side of Lemmon, the high wind which prevailed there blew a box car from a siding onto the main track. The car was taken over the rails by the wind at a merry clip, and despite the fact that the passenger was making good time to make up for the 40 minutes lost, the box car overtook it and bumped into the rear of the train. No damage was done and the box car was permitted to travel with the passenger until a siding was reached, when it was switched off.

Lessons of the Necaxa Dam Failure.

Engineers interested in dam construction the world over will follow with interest the account given in this issue of the great slide in the Necaxa dam, under construction in Mexico.

Mr. Jas. D. Schuyler, the Engineer of the structure, gives a plain account of what occurred and the photographs accompanying his article show clearly the situation at the dam. The striking and impressive fact is that the whole interior of this huge structure appears to have been a mass of semi-liquid clay. That this semi-liquid central mass exerted a hydrostatic uplifting pressure on the rock slopes which confined it on either side is clearly evident. Finally this pressure became sufficient to force upward the rock slope on the upstream side, and through the breach thus formed, the soft fluid clay in the interior of the dam flowed outward almost like water. Some of this material appears to have flowed some 1,200 to 1,500 ft. from its original position.

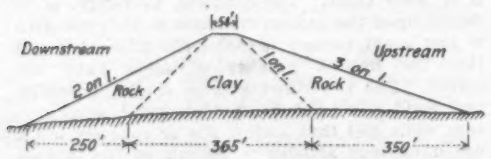
The lessons which this disaster conveys are important and impressive, and it is well that they should not be misunderstood. Foremost of course is the necessity of providing for proper drainage in earth dam construction, and particularly for dams built by the hydraulic process. No doubt most engineers engaged in dam construction do understand the desirability, as an abstract matter, of securing good drainage for the puddle core of an earth dam; but this Necaxa disaster is calculated to make every engineer realize that this is actually a vital matter, particularly in dams built by the hydraulic process.

There will be those, very likely, who will point to the Necaxa disaster as a final condemnation of all hydraulic-built dams, or even of earth dams in general. Such conclusions, however, are far too sweeping. The layman may be excused for such conclusions, but they are unworthy of the engineer. It were as reasonable to condemn masonry dams because of the failure of the Austin dam or the dam at Columbus, Ga., or cantilever bridges because of the fall of the Quebec Bridge.

On the other hand, the question may well be raised whether the choice of the hydraulic method of construction for the dam at Necaxa, under the conditions there existing, was a wise one; and, indeed, whether it is ever advisable to place a core *of pure clay* for a dam by the hydraulic method.

Undoubtedly the hydraulic method of earth excavation works best in sand and gravel. Banks of these materials built hydraulically promptly drain themselves and become stable. Banks of mixed clay and sand also may be built by this method without difficulty or danger; but when the clay becomes so large a proportion of the whole that the embankment stays soft for a long time, then the engineer is treading on dangerous ground.

At Necaxa, we are informed, there was no sand to be had for dam construction. Pure clay and broken rock were the only materials available. It was expected that the broken rock sides of the dam would drain away the water from the clay in the center and cause it to solidify. From Mr. Schuyler's account, this drainage appears to have taken place to some extent and for a thickness of 8 to 10 ft. the clay appears to have drained out and hardened. From here, inward, however, it is evident that the clay remained in semi-liquid form, and the pressure it exerted brought about the catastrophe.



Typical Cross-Section of Necaxa Dam as Designed.

Lacking full knowledge of the local conditions, we may not pretend to speak with authority; and we are commenting on the accident in any event chiefly for the lessons it may teach to builders of dams elsewhere. With this proviso we venture the criticism that the hydraulic method of construction seems to have been ill-adapted to this particular excavation. The materials to be excavated and transported were clay and broken rock, neither of which are well adapted to excavation by the hydraulic jet or to carriage in flumes. At Necaxa, in fact, it was necessary to line the flumes with steel plates and give them a very steep slope to carry the broken rock. As for the carriage of clay by water, the difficulty in getting rid of the water has already been sufficiently described, and besides, a considerable percentage of the finer clay is always carried off in the overflow.

Had the clay and rocks at Necaxa been transported by ordinary methods, such as cableways or cars and locomotives, the clay might have been placed in the dam with the proper consistency to compact well but without the surplus moisture that proved so disastrous.

And we venture the suggestion, further, in view of this experience at Necaxa and also the slide on the Wachuset dike two years ago, whether enough attention has been given to insuring *stability* in the design and construction of earth dams compared with that devoted to securing water-tightness. At Necaxa, for example:

> More rock and less clay
> Would certainly have saved the day.

If the couplet serves to fix in the reader's mind the importance of stability in earth dam construction, the value of the combined rock-fill and earth dam type of structure and the importance in carrying it out of making the rock-fill part massive enough for the work it has to perform, then the introduction of the rhyming couplet in an article of this character will probably need no further excuse.

The Present Problem as to the Pollution of Lake Michigan.

The pollution of Lake Michigan, and the consequent danger in its use as a source of public water supply, has become a serious matter to several cities at the south end of the lake, and even threatens Chicago, notwithstanding the great expense which that city has incurred to divert its own sewage from the lake. Lake Michigan, in its natural state, affords an unlimited supply of water of excellent quality. To supply the cities around the southern end from other sources would be enormously expensive and in some cases quite impracticable. The lake has long been utilized also for sewage discharge, and as the water near shore has become polluted, waterworks intakes have been established farther and farther out in the attempt to get pure water from beyond the limits of pollution. The rapid industrial development and growth of population around the south end of the lake in the last few years, however, has brought about serious conditions in the way of increased pollution and increased danger to public health. The pollution consists partly of sewage from various small (but rapidly growing) cities and towns, and partly of wastes from large industrial plants, the sewage and wastes being discharged either directly into the lake or into streams which are tributary to it. These conditions have been set forth in papers presented before a number of engineering and technical associations within the past few months.

It has been pointed out that owing to the number of different state and municipal interests involved, no effective solution of the problem could be arrived at or carried into effect without cooperative and concerted action by these several interests. In our issue of Dec. 17, 1908, we published an abstract of an address by Mr. John W. Alvord, M. Am. Soc. C. E., suggesting the establishment of a sanitary district to include the entire district bordering upon the south end of the lake, so that control of all sewage disposal and water supply problems would be concentrated in the hands of one authority.

In 1908, also, an organization was effected for the purpose of cooperating in the investigation of the conditions and the consideration of remedial measures. This is known as the Lake Michigan Sanitary Association. It includes representatives of the federal government, four state governments, several municipalities, state and municipal boards of health and sanitary experts. At a meeting held in Chicago early in 1909 the association decided that the legislatures of Illinois, Indiana, Michigan and Wisconsin should be urged to pass laws providing for the cessation of pollution of the lake. This great body of water, of excellent quality, is to be regarded as a necessary and valuable asset to the municipalities and population upon its shores, and its abandonment on account of pollution by sewage and industrial wastes is not to be thought of. While this movement is a good one, it will be a long and tedious matter to obtain the legislation required.

The city of Chicago has diverted its sewage from the lake through the medium of the drainage canal, and has extended its newer waterwork intakes into deep water at such a distance from shore as to be practically beyond the limits of shore pollution. These limits have sometimes extended out as far as the two-mile crib, but have never yet reached the four-mile crib. Pollution from the south is now threatening, however. The quality of the Chicago water is not as permanently good as it should be, and is at times open to suspicion as a possible source of typhoid fever. This is shown in a paper published in the 1909 "Proceedings" of the Illinois Society of Engineers and Surveyors, by Dr. W. A. Evans, Health Commissioner of Chicago and President of the sanitary association mentioned above. He stated that Chicago is not altogether safe from water-borne typhoid, and that the large proportion of colon bacilli in the water during the past year points to the possibilities of an epidemic of typhoid fever at some future time unless the conditions responsible are remedied.

Two conditions are held responsible: (1) the dumping of river dredgings near the shore; (2) the discharge of sewage and wastes into the south end of the lake. As to the first, this was permitted at a time when the lake was already polluted by the flow from the Chicago River, and it was held that the dredgings from the river would add little to the danger. At the present time no sewage is discharged into the lake north of 85th St., and Dr. Evans considers that it is not safe to deposit the dredgings within five miles of the intake cribs. At the same time, he states that he has been surprised to find how small is the amount of colon bacilli and organic matter in these dredgings.

The more serious pollution is that due to the sewage and wastes discharged into the south end of the lake, the quantity of the discharge increasing rapidly with the development of this district. It has been thought that by a proper location of sewer outlets and water intakes with relation to certain lake currents there would be little or no danger of pollution reaching the intakes; but investigation has shown that there are no fixed currents. The course of the polluting matter varies with the direction of the winds, and it is practically impossible to establish intakes which will be out of their course, except at large expense for long tunnels to reach intakes in deep water beyond the probable limits of the pollution. We quote Dr. Evans as follows on this point:

> Last year they [the Lake Michigan Sanitary Association noted above.—Ed.] began a study of the water conditions along the shore. The interests of Illinois are so nearly the same as the interests of Indiana that no political line, no city boundary line, suffices to divide them. They established a branch laboratory at Indiana Harbor. A tug was chartered which traveled each day from the 73d St. crib (Chicago) to a point 35 miles east of Indiana Harbor and they took water from Lake Michigan at about 50 points within a distance of five miles from shore. These samples were transmitted to the laboratory.
>
> It was found that there is no fixedness of current in Lake Michigan; that the direction of the currents is dependent altogether upon the prevailing winds. They found that five miles of flow through the waters of Lake Michigan did not serve to purify sewage when that sewage was in quantity. For instance, the tug would go from the mouth of the Calumet River and steam right down the wind and every half mile or so they would take samples of the water. It was easy to map out the line of sewage flow from the mouth of the Calumet River for a distance of seven miles into the lake, the direction depending upon the direction of the wind. They proved that all of the water down in that district was contaminated at all times. For instance, they observed that when a west wind was blowing, 80% of the sewage of Whiting, Ind., found its way right over to the intake supplying water to the people of Whiting.
>
> The conclusion is irresistible that all sewage must be kept out of Lake Michigan, whether that sewage flows directly into the lake or whether it flows into streams that eventually flow into the lake. Let me illustrate that point. East Chicago is building a ditch to carry its sewage into the Calumet River, feeling that it will thus improve the water supply. They empty that sewage into the Grand Calumet and it flows down into the common Calumet and into Lake Michigan. Then, if there is a wind blowing, it is blown directly back over the intakes of the water supply of Hammond, Whiting and East Chicago. In other words they have not got rid of their problem by carrying their sewage into the Calumet River, although they have increased the dangers to the people of Chicago from that disposal of their sewage.

The proper remedy, evidently, is to prevent the pollution of the water of the lake, rather than to avoid the polluted water. The suggestion has been made many times that a canal should be built from the Calumet River (near the south end of the lake) to the Chicago drainage canal, reversing the flow of the river and thus eliminating the main channel of the pollution. Outfall sewers from neighboring towns, etc., could discharge sewage into this canal instead of into the lake. Such a canal is projected by the Sanitary District of Chicago, but is delayed pending litigation with the government as to the quantity of water to be drawn from the lake. This suit

was reviewed in our issue of May 27, 1909. It is considered by the chief engineer of the District that such a canal should be built in any event, as a sanitary measure, using such amount of water as the government might permit.

Another proposition is to establish large filter beds for sewage disposal south of Chicago, where there are great areas of sand, and the suggestion has been made that it might be practicable to operate such a plant for the joint service of several municipalities. Such a location was proposed by Mr. Rudolph Hering, M. Am. Soc. C. E., for a filtration plant to dispose of Chicago's sewage in the future, when the permissible quantity of water that may be drawn from the lake will not suffice for the dilution of the increased quantity of sewage due to the growth of the city. The Sanitary District of Chicago has in fact decided upon the construction of an experimental sewage purification plant, with a view to the future treatment of (1) the sewage of small municipalities within the District, which may be remote from the canal, and (2) the treatment of that part of the city's sewage which is in excess of the dilution capacity of the canal.

Apart from the Chicago problem, however, it is very evident that conditions along the south end of Lake Michigan are serious enough to demand prompt and energetic action to protect the water supply (and the public health) of the present cities and towns and of the new municipalities and manufacturing plants which are growing up rapidly with the great industrial developments within this district.

LETTERS TO THE EDITOR.

Concerning the Annual Golf Tournament of the American Society of Civil Engineers.

Sir: The Annual Golf Tournament of the American Society of Civil Engineers was satisfactorily completed at Mount Washington last week. The prizes will be duly announced. It has been suggested that the letter "G" may be placed in the catalog opposite the names of the victors, in due appreciation of the society's indebtedness for their work.

A few members of technical tendencies appeared disappointed that the four days passed with so little attention to engineering questions. In deference to their protests, after some discussion and bright scintillations from our Irish Wit, it was decided that technical discussions should not be omitted during the present season; but future Am. Soc. C. E. tournaments will not be interrupted by anything which savors of serious thought.

President Bates' address indicates that all is not well in the civil engineering profession; but like a famous Roman emperor, we are content to fiddle while a conflagration proceeds.

M. Am. Soc. C. E.

Boston, July 12, 1909.

Concerning the Alleged Suction of Automobile Tires.

Sir: I have just read with much interest the article on p. 46 of your issue of July 8, entitled, "Concerning the Wear of Roads by Automobiles." I do not disagree at all with your conclusions as to the damage done to roads by the tangential action of the tires and the shearing effect thus produced, but I do not think you attach enough importance to the so-called "suction" of the tire. I have had the opportunity to note carefully some experiments which seem to indicate that automobile tires do exert a very strong suction on the loose dust of the roadway. If you will duplicate the experiments upon which I base my theory, I think you cannot fail to arrive at the same conclusion. The matter may be easily determined by driving an automobile at high speed over a macadam surface and at a given point shutting off the power, or what is equivalent, throwing the clutch out of gear. The machine is then left to "drift" under its own momentum. Careful observation of the road surface will show little or no difference in the effect on the road before and after the power has been cut off.

The principal reason why a flat steel tire does not produce the same effect upon a macadam road as is caused by a rubber tire is that the steel tire does not fit so perfectly into the small inequalities of the road surface. If you will take a 4-in. flat steel tire and roll it over a perfectly smooth wooden floor, the surface of which has been lightly covered over with fine road dust, you will find the same "suction" effect as is produced by the automobile tire upon the road, or the same principle may be tested by placing one's foot upon a dust-covered floor and removing it from the surface with a motion similar to that by which the automobile tire leaves the surface of the road. In both of the latter two experiments the dust will be found to have been drawn together from the sides of the wheel tread and piled in a "windrow" in a line midway of the path followed by the wheel tread.

To my mind, these experiments show conclusively that the element of "suction" must be valued more highly than is suggested in the closing paragraphs of your article.

Yours very truly,

R. D. Beman,
Deputy Commissioner.

State Highway Department, Harrisburg, Pa., July 11, 1909.

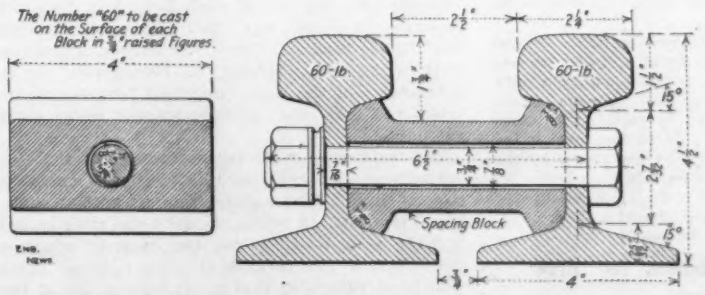
[We had and have no doubt that the "suction" of the rubber tire moves the loose dust of the roadway. What we denied was that this "suction" is sufficient to tear loose the firmly bound materials in the hard cemented surface of the road. The limit of any "suction" effect is less than 15 lbs. per sq. in., even when a piston is moved in a cylinder with full atmospheric pressure behind and a perfect vacuum in front. It is difficult to believe that the suction effect on the road surface at the instant the tire lifts from it can be more than a few ounces per sq. in., for the air contained in the pores or microscopic crevices of a hard macadam surface is small in amount and has more or less free escape to the surface through these crevices. Compare this force, even if it amounted to pounds instead of ounces, with the tangential push of the propelling wheels or the shear due to the varying diameter of different parts of the tire and it is easily seen that "suction" is not the chief cause of the destruction of roads by automobiles.—Ed.]

Curve Guard Rails on the Queensland Government Railway (Australia).

Sir: I have been much interested in the article which appeared in your issue of June 4, 1908, on "A Review of Standards of American Railway Track Construction," but owing to pressure of business I have been unable to look into the subject closely until now. My attention has been drawn particularly to the subject of "guard rails on sharp curves," as for some years past we have been experimenting in this direction, and I am pleased to say with very satisfactory results. Prior to the introduction of guard rails on our railways, the average life of the outer rail for curves of the following radii on one of our mountain lines was as under:

Radius of Curve.	Degree of Curve.	Life of Outer Rail.
330 ft.	17° 22′	16 months.
363 ft.	15° 47′	18 "
396 ft.	14° 28′	21 "
528 ft.	10° 51′	28-30 "

The shortest life recorded on a 5-chain curve (330-ft. radius) was 11 months. The principal factor determining the life for curves of the same radius appears to be the grade, it being found that the steeper the grade the shorter the life. This is due, no doubt, to the greater amount of braking.



GUARD RAILS FOR SHARP CURVES ON THE QUEENSLAND RAILWAYS (AUSTRALIA).

It has been found that by the introduction of guard rails on curves of 17° the life of the outer rail (taking the average of a number of curves) has been increased to 3 yrs. 3 mos. In fixing guard rails, second-class rails which have already been used on curves, are utilized, the unworn side being placed next the running rail.

I attribute the increased life of the outer rail that accrues by the use of guard rails to the following causes: (1) the greater area of guard rail subjected to abrasion by wheel flanges, which wear the guard rails vertically; (2) the lubrication that takes place, due to the greasy condition of the back wheel flanges, and to the fact of the rails being periodically oiled by the section men.

Guard rails were first introduced extensively on our railways on 5-chain curves in June, 1898, at bridges and on high banks. They were spaced 2½ ins. from the running rail, and secured to the same by ¾-in. bolts, with spacing ferrules made of 1-in. gas pipe. The bolts were first placed 2 ft. apart, which was subsequently increased to 3 ft. Owing, however, to some derailments on 5-chain curves (mostly, by the way, with engines running down hill at low speeds) all 5-chain curves were protected with guard rails. This was carried on in the latter part of 1900, and it will be observed that it was done in the interests of safety. Since then, however, finding that engine loads had not decreased, I have been advocating their use for the sake of economy.

I observe that on American railways the guard rails are secured by transverse tie rods passed through the webs of the rails, but this design of fastening does not appear to me to be a desirable one. (This is incorrect.—Ed.) We have tried several methods in this connection, and have now decided upon securing the guard rails with cast-iron blocks and bolts as illustrated in the accompanying cut. This is the most effective attachment we have tried, and precludes any necessity for tie rods. We found that when using the bolts and ferrules already mentioned the guard rails canted over with the pressure exerted by the wheel flanges, thereby allowing the outer rail to take the most of the wear.

With guard rails a derailment cannot occur until the space between the running and guard rails allows the wheel to drop between the rails, or an interval of 4½ ins. with the smallest width of wheels in use.

It is considered perfectly safe practice to allow the outer rail to remain until the interval between the guard and running rail is 3 ins. and the gage 3 ft. 7 ins. (standard gage on these railways is 3 ft. 6 ins.) This extends the life of the outer rail nearly three-fold, or gives 5 to 6 times the life as compared with rails without guards. Allowing ¼-in. wear in the wheel flange, the wheel tread has not less than 1⅛ ins. bearing on the rail head.

The cost per 100 ft. of laying guard rails, using cast-iron spacing blocks, is as follows:

	With 41¼-lb. rails.	With 60-lb. rails.
Material	$38.60	$57.10
Labor	9.40	13.12
Total	$48.00	$70.22

Rails at $40 per ton, freight charges to be added. Labor, section foremen, from $1.80 to $2.28 per day; section men, from $1.44 to $1.92 per day.

The cost of distance blocks has been 29 cts. and 18 cts. each for 41¼-lb. rails and 60-lb. rails, respectively.

I have taken the liberty of addressing you on this subject with the hope that the remarks I have made may be of use to you in any further investigations you may make with regard to railway construction matters.

Yours faithfully,

W. Pagan,
Chief Engineer, Queensland Railways.

Brisbane, Queensland, April 22, 1909.

[Our correspondent is under a misapprehension regarding the fastening of curve guard rails to running rails on American railways. In some cases they are secured only by spikes and rail braces, but in other cases they are secured to the running rails by bolts with spacing blocks, very much as shown in the cut and in the same way as frog guard rails are secured to the running rails. Tie-rods are occasionally used as an alternative for guard rails, the tie-rod anchoring the outer rail against the inner rail to resist the lateral pressure of the wheel flanges. The guard rail at the inner rail, however, serves to hold the wheels away from the outer rail. Tie-rods on curves are used to only an extremely limited extent, and guard rails might be used more extensively as a precaution and as a means of reducing track work.—Ed. Eng. News.]

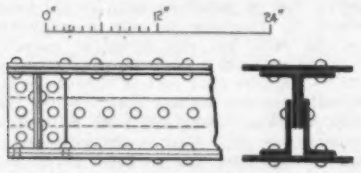
Bending Stresses at Eccentric Joints of Trusses and Effective Depth of Plate-Girders.

Sir: I write to emphasize a correction made by and to correct an error in a foot-note to an article, in your issue of June 10, on "Some Faulty Details in Structural Steel Work," referring to a joint in a Warren truss in which (1) the positions of the web-members are eccentric with respect to the chord, and (2) the lines of rivets

connecting the webs to the chord are eccentric with respect to the gravity lines of the web-members.

The error referred to consists in omitting the stresses due to the eccentric position of the members and considering only the direct stresses plus the stresses from the eccentricity of the rivets in obtaining the "total extreme fiber stresses." In the members in question, the stresses due to the eccentricity of the joint are quite high, while the stresses due to the eccentricity of the rivet lines are small and tend to reduce the totals in the short distance in which they occur.

The correction made by the foot-note referred to is the substitution of the small amount (3,620 lbs. per sq. in.) of stress due to the eccentricity of the rivet lines



Extreme Case of Shallow Riveted Girder.

in place of the large amount given by the author of the article.

It is not an infrequent mistake for critics of structural details to assert that a member connected to a stiff connection or web plate by a line of rivets which is eccentric with respect to the axis of the member is subjected to a bending moment equal to the eccentricity multiplied by the *total stress* received from the rivets. Even "The Engineering Record" in an editorial on "Questions of Plate Girder Design" in their issue of Aug. 22, 1908, made the following statement:

> The depth of a truss is obviously the vertical distance between the centers of pins in the top and bottom chords, or the vertical depth between the centers of gravity of the same chords when they have riveted joints. The depth of a plate girder is just as certainly the vertical depth between the lines of rivet holes in the top and bottom parts of the web plate, and that depth ought to be used in computations just as much as the universally accepted depth of a pin-connected truss. This has been recognized occasionally, but the general practice is to consider the depth between centers of gravity of flanges as the true depth for computation purposes. This procedure results in an error of some proportions in girders whose depths are not very great besides a failure to recognize bending stresses of some magnitude in the flanges, especially where cover plates exist.

The mistakes of these critics arise from a failure to realize that a member connected to a stiff plate by a line of rivets which is eccentric with respect to the axis of the member, is not permitted to deform to the extent necessary to develop bending stresses corresponding to the moment of the entire stress multiplied by the eccentricity, but is compelled, instead, to act with the plate almost as one piece. The tendency to independent deformation on the part of the member modifies the directions of the rivet pressures and thus causes the bending moments from the eccentricities of these pressures to so far neutralize each other that the total bending moment on the member at any point from rivet pressures is ordinarily limited to one rivet load multiplied by the eccentricity of the line of rivets, as stated in the foot-note previously referred to.

That the use of the depth between the centers of the rivets by which the flange-angles of a girder receive their stresses can not always be relied on, even as a fair approximation, in dealing with "girders whose depths are not very great," can be readily understood after attempting to apply the rule to the computation of flange stresses in girders like the one shown by the subjoined sketch.

Respectfully,
Henry S. Prichard.

1526 Frick Bldg., Pittsburg, Pa., June 14, 1909.

Formulas for Cable Stations for River Measurements.

Sir: Permit me to call your attention to a mistake in the derivation of the very interesting and useful formulas and tables in the article on the design of cable stations for river measurements in your issue of May 6, 1909. The length of any flat arc over the base b and with the height h is approximately,

$$\text{length of arc, } c = b + \frac{8h^2}{3b},$$

and therefore, using the notation of your article, the length of the loaded cable, which hangs in two arcs (formula 6 page 484) ought to be

$$l = 2\left(\frac{c}{2} + \frac{8s_2^2}{3\frac{c}{2}}\right) = c + \frac{32s_2^2}{3c} \qquad (6)$$

whence, in place of the author's formulas (7) and (8), there results:

$$l = c + \frac{2s_1^2 r^2}{3c} \qquad (7)$$

and

$$s_1 = s\sqrt{\frac{12}{16 - 4r^2}} \qquad (8)$$

In taking $s_1 = 0.87s_0$ the inaccuracy will be somewhat greater than the author puts it, as will be evident on comparing his formula (8) with that given above. But as it will be almost impossible to adjust the cable to the proper sag within 3% or even 5% in the field, and as the modulus of elasticity of cables depends largely upon load, age of the cable, time of application of the load and many other factors, so that the value of 22,000,000 can be no more than a rough approximation, the tables by Mr. Stevens will still be very useful, not only in river work but for many similar cases.

Yours truly,
K. A. Muellenhoff, C. E.

Eisenwerk Kaiserslautern, Kaiserslautern, Germany, June 8, 1909.

Formulas for Water Pressure and Moments in Submerged Beams.

Sir: I wish to call your attention to an error on page 575 of the May 27 issue of your paper, in the "Summary of Reactions and Maximum Moment of Various Gate or Needle Beams." Case I B, third column should be

$$e - \sqrt{\frac{e^2 + ea + a^2}{3}}$$

instead of

$$e\sqrt{\frac{e^2 + ea + a^2}{3}}$$

Yours truly,
A. W. Lowe.

Lynn, Mass., June 15, 1909.

[The formula is given correctly in the text, Eq. (15), p. 573, but wrong in the tabular summary, where the minus sign was omitted.—Ed.]

Tests on the Fire-Resistive Properties of Various Building Materials by the U. S. Geological Survey.

For the past two years the Structural Materials Branch of the U. S. Geological Survey, which has its headquarters at the Structural Materials Laboratory, at St. Louis, Mo., has been engaged, among other matters, in fire tests of a number of materials which are in use as fire-resistive or partially fire-resistive building materials. Although the work is not anywhere near completion, it has progresssed far enough to warrant the publication of a bulletin* describing the results of tests on 30 panels made up of mortar and concrete building blocks, concrete, terra-cotta tile, sandstone, granite and marble. This bulletin gives a detailed description, with illustrations and curves, of each test, but does not presume to make any final deduction, leaving that to the reader. There is, however, a preface, written by Mr. Richard L. Humphrey, which notes some of the most important features of the tests, and from that preface we will make some extracts.

The tests were made in the furnace of the Underwriters' Laboratories in Chicago in the first part of 1907. This furnace has an arched opening, 6 ft × 9 ft., in which the material to be tested is built as a wall against the back of which a gas fire from the furnace is made to play. This wall is on rollers so that it can be run out of the furnace door into the open where a stream of water can be thrown against it. There are provided pyrometers and thermocouples by means of which temperatures on either side of the wall can be read at any time. In the tests the opening was carefully filled with the material to be tested, the furnace started and continued for two hours and then, except in five out of the 30 panels, the heated side quenched with a 5-minute application of 50 lbs. per sq. in. of water coming through a ⅞-in. nozzle 20 ft. from the panel. The temperatures varied between 1,400° and 1,700° F., maximum, most often the latter.

The 30 panels tested were made up of the following materials: cement mortar building block, 13; clay brick, 3; sand lime brick, 1; clay tile, 3; concrete (pieces of broken beams), 4; sandstone, 1; granite, 1; mixed building stone, 1; marble, 1, and limestone, 2. Of the mortar blocks, made with various mixtures, some were the single air-space type and some were the double, and both Meremec sand and slag sand were used. The concrete blocks were pieces of test beams broken in flexure and were made with limestone, cinder, granite and gravel aggregate. The clay tile were the stock multi-cellular blocks and bought from a yard. The building blocks were of standard stones cut to convenient sizes. All the materials were set tight in the door and mortared in.

Whenever possible, tests were made to determine the compressive strength of the materials after the heat and quenching treatment.

So much for the general nature of the tests; the observations upon them noted above are in part as follows:

The conditions under which these tests were made were unusually severe and none of the material passed perfectly. The temperatures used would hardly be reached in an ordinary fire. It was recognized from the beginning that these tests would not be comparable with those made by other investigators. The relatively few tests that have been made of the fire-resistive qualities of building materials nearly all consisted of subjecting floor slabs and columns to the heat of a wood fire. There is reason to believe that the tests herein described, made in a gas furnace, are more severe than the tests made with a wood fire, even though the latter show higher temperatures and last longer. In the gas furnace the flames are forced by a blast of air against the panel from the beginning to the end of the test; with a wood fire the heat fluctuates and falls decidedly when the furnace door is opened and fresh fuel is added.

Much of the damage done to the building materials in this series of tests was occasioned by internal stresses, the gas flame heating one face of the test pieces much more rapidly than the other face. All the materials tested, including the hydraulic-pressed brick, cracked more or less. The concrete cracked least, but the tests indicate the necessity for using metal reinforcement in concrete walls to distribute the effect of the expansion.

The average temperature attained by the faces of the panels 10 minutes after the gas was lighted was about 615.2° F. and nearly half of the panels had been subjected to freezing weather just prior to the tests. The average temperature of the face of one panel of building blocks rose from 32° to 842° F. in the first 10 minutes of firing, while that of another panel of the same material ranged from 71.6° to 1,112° F. during the same interval.

Although the results obtained from these tests will not be critically analyzed in this bulletin, a few of the more important features will be pointed out.

A fact brought out most clearly by these tests is the low heat transmission rate of Portland cement mortars and concretes. This is one of the desirable qualities in materials intended for fireproofing purposes. For marking the cement blocks linen tags were fastened by wire nails to the interior walls at the time of molding. Most of these tags remained in place during the test, and when the walls were dismantled the tags in every case were found entirely undamaged.

There was a comparatively slight increase in the temperatures of the backs of the blocks during the test. The rise in temperature of the backs of the building blocks made of river-sand mortar varied from 77° to 104° F., while the rise in the average temperatures of the faces of the cement blocks ranged from 1,202° to 1,652° F. The backs of the mortar blocks, made of slag sand, showed a rise of temperature of only 30° F., while the faces were heated up to 1,472° F. The low rate of heat conductivity of the mortar blocks is shown by the slowness with which the temperature of the backs of the panels increased in comparison with that of the faces.

An average of all the tests shows that about 90% of the maximum temperatures attained by the faces of the panels were reached in one hour, while in the case of the mortar blocks the increase in temperature of the backs of the panels in one hour was only about 20% of the total increase in the two hours. Of the solid concrete panels the cinder concrete showed the smallest increase in the temperatures of the backs of the walls, and the granite concrete the largest. The total increase in the temperatures of the mortar panels was about the same as the total increase in the temperatures of the backs of the concrete, but the increase in one hour was somewhat greater in the case of concrete.

The damage done to the faces of the mortar and concrete panels would probably be caused at a temperature about half that of the maximum temperatures reached, owing to the water of crystallization being driven from the mortar. This thin layer of dehydrated mortar may have formed a protective coating and prevented deep dehydration.

The backs of the brick panels also showed a small increase in temperature, but the natural building stones

*The Fire Resistive Properties of Various Building Materials, by Richard L. Humphrey. Bulletin No. 370, U. S. Geological Survey, 1909.

and the tiles proved poorer non-conductors of heat. The temperature of the back of a panel composed of plaster tiles increased to 262.4° F.

It is apparent that the strength of the webs of ordinary hollow blocks is insufficient to resist the stresses set up in these tests, as in many tests the rapid rise in temperature and the subsequent quenching of one of the faces of the blocks caused the webs to split. It was noticeable that the richer the mortars used in these blocks the better they withstood the tests. The amount of water used in mixing the mortars had a similar effect on the fire-resistive qualities; the mortars mixed with the greatest percentage of water gave the best results. This may be clearly seen in the photographs of the mortar blocks after the water treatment, where the wetter, richer mixtures often stand out apparently undamaged, in contrast with the spalled, damaged faces of the leaner, drier bricks.

When blocks were cracked or spalled before the application of the water the damage appeared to be greater in the dry mixtures containing the greatest percentage of sand, and it was further observed during the fire test that the richer mixtures warmed up more slowly than the others. It is apparent that one of the causes of weakness in the hollow cement building blocks under these fire tests was the weakness of the concrete, a too dry and lean mixture, which, coupled with the thinness of the webs, provided insufficient strength to resist the stress due to the rapid expansion of the face. It is quite possible, as was shown in some of the block tests, to make blocks which will pass the conditions perfectly; the web must be thick enough to give the necessary strength.

A close examination of the blocks that had not been quenched showed that the 1:2 blocks were seldom affected by heat to a greater depth then ¾ in., while the 1:8 blocks frequently showed the effect of the fire to a depth of 2 ins. The blocks made of slag sand resisted the test better than those made of river sand. Before the water was applied to the slag-sand blocks no damage was apparent, although it must be remembered that close examination of the panels between the fire and water treatments could not be made on account of the heat. After the quenching the faces of the 1:1½ slag-sand blocks were found to be washed away to a depth of ¼ to ⅝ in.; and those of the 1:2½ to a depth of ½ to ⅝ in.; while the 1:4 mixtures were damaged only to a depth of ½ to ¾ in. The surfaces were rough and pitted, but hard. In only one block was the web cracked through.

There was great difficulty in getting accurate results from strength tests of irregularly shaped fragments from the backs and fronts of blocks after the fire and quenching tests, and the results are too inconsistent to be conclusive. The average compressive strength of the faces of blocks was about two-thirds to three-fourths of that of their backs, varying with the proportions and consistencies.

The brick panels probably withstood the tests better than the other materials. The common brick tested comprised unused new Chicago brick, and used St. Louis brick. Fifty per cent. of the new bricks were split, while 60 to 70% of the old bricks were not damaged. Lime knots seemed to be responsible for most of the damage to the new bricks, as they were found at the bottom of nearly all the cracks. The bricks at the back of the panels were entirely unaffected. While the strength tests are not conclusive, there is apparently little difference in the strength of these bricks before and after firing.

The hydraulic-pressed brick withstood the test very well. No damage was apparent after the firing and before the water was applied, and although a number of the bricks cracked, 70% of them were found to be sound after quenching.

The sand-lime brick did not withstand the test as well as expected, but the sample tested, which was purchased at random, appeared to be somewhat below average quality.

It was difficult to determine whether the limestone, granite, gravel, or cinder concrete sustained the least damage. The faces of all the panels were more or less pitted by the fire and washed away by the stream of water. The test was unfair to the cinder concrete, as the cinder was very poor, containing a large percentage of unburned coal; however, the sample selected was the best of six or eight investigated in St. Louis. During the fire test the coal ignited and left the surface of the concrete very rough and badly pitted. The limestone aggregate in the face calcined, and the granite aggregate split and broke away from the surface mortar. The granite concrete probably behaved the best. The damage in no case extended deeply, probably not more than 1½ ins. The evidence shows that even at this depth the temperature was comparatively low. The high stresses produced in the panels by the rapid rise of temperature of the faces while the backs remained cool caused cracks. On taking down the panels the blocks of concrete were found to be cracked vertically for some distance back from the face.

The serious damage to the various natural building stones precludes any comparison among them.

The tile tested was bought in the open market, and in one panel was taken from a lot of material about to be erected in a building. Large percentages of the faces of the tiles were washed away by the water, and the material composing the faces became soft and could be easily crumbled in the fingers. There was a comparatively rapid rise in the temperature of the back of the panels. The plaster on the panel of partition tile fell off a few minutes after the test was started.

Heretofore fire tests of building material have been made at random and scarcely any two tests are comparable one with the other; it is therefore hoped that the next series of tests made in this type of furnace, where with the experience gained the conditions can be more closely controlled, will lead to much more valuable results.

Annual Convention of the American Society of Civil Engineers.

The forty-first annual convention of the American Society of Civil Engineers was held at the Mt. Washington Hotel, Bretton Woods, N. H., July 6 to 9. The mountain scenery, the weather, the notably satisfactory service at the hotel and the good fellowship of members and guests in attendance at the convention, all combined to make the convention a success. The business and technical proceedings, as is usual at these summer outings, were kept well in the background, but were sufficiently in evidence to satisfy the consciences of most of those present who felt that a convention of engineers should not fail to discuss engineering matters in a formal way. The small attendance gave rise to considerable comment, and could hardly be explained in view of the attractiveness of the meeting place and its nearness to New York. A few suggested that more extended technical proceedings would have lengthened the registry list.

The convention opened on Tuesday forenoon with a well-presented and well-received address by Mr. Onward Bates, President of the Society. An abstract is printed elsewhere in this issue.

Committee reports were considered and other business transacted on Wednesday evening. Three topical discussions were held on Thursday afternoon. Numerous short excursions were made and there were various social events during the four days of the convention.

Of two committee reports scheduled for presentation the one on "The Status of the Metric System" (Proc. Am. Soc. C. E., Oct., 1908) gave rise to no discussion, save a written communication, which was not read. The case was different with the "Report of the Special Committee on Concrete and Reinforced Concrete" (Proc. Am. Soc. C. E., Feb., 1909—majority and minority reports). Three members sent in written discussions and a larger number discussed the report orally.

Major John S. Sewell wrote that he felt compelled to agree with the minority report in nearly every particular. He named many points which, in his opinion, needed further consideration by the committee. Among these were: the effect of common salt, of manure, of oils and of ensilage on concrete; the value of M in the formulas recommended by the committee; web stresses; columns and footings. In conclusion, Major Sewell wrote that he thought the majority report did not do credit to the able personnel of the committee, and that the report should be referred back for further consideration.

Mr. Clarence W. Noble sent in a lengthy written discussion of the report, in which he described various tests, which he had made, of reinforced-concrete slabs and floors. He had found by tests that re-rolled rails gave satisfactory results as reinforcing members. He made slight adverse comment on the majority report. Mr. S. Bent Russell supported some of the points made by the minority members of the committee.

All who discussed the report orally supported the majority members, except that Mr. John F. O'Rourke expressed himself forcibly and picturesquely against admitting that reinforced concrete may rightly be considered as a unit material.

Mr. J. R. Worcester, a member of the majority of the committee, made a dignified defence of the conclusions of the majority. Prof. L. J. Johnson and Prof. Geo. F. Swain each stood up for the majority report. Mr. Richard Humphreys, Secretary of the committee, stated that 27 of the 33 members of a committee of the Railway Maintenance of Way Association had voted in favor of the recommendations of the majority report. Finally, a motion to accept the report of the majority and print it in the Transactions of the Society was adopted.

Discussion of the topic, "Fire Resistant Construction in Buildings," was opened by extracts from a lengthy paper sent in by Mr. Herbert M. Wilson. This paper embodied some of the results of investigations made by the Technologic Branch of the U. S. Geological Survey for the Commission on the Conservation of Natural Resources. Many statistics of fire losses in the United States were given, and these were compared with European fire losses, which are much less than American, when reduced to a unit basis. Wiser choice of building materials and improved building codes were suggested as means of reducing American fire losses. Several who took part in the discussion of this subject also spoke of the need of more restrictive state and municipal legislation against fire dangers. Attention was called to the French practice of making the owner of a building in which a fire originates pay the damages caused by the spread of the fire to other buildings. Mr. Samuel Whinery suggested that the distribution to the whole community of American fire losses through an excellent fire insurance service tends to irresponsibility on the part of owners of fire risks.

Another subject for topical discussion was "Impurities in Sand for Concrete." This discussion was opened by Mr. Sanford E. Thompson, who gave some interesting details of an investigation which he made of the failure of a concrete building. The failure was traced to the use of a sand containing, in its included silt, considerable vegetable matter which appeared to have washed down from the turf into the sand bank. The lesson from this incident, and the lesson was reinforced by strong expressions of opinions by other speakers, was that sand as well as cement should be carefully tested, and that the test should be of material from mortar box.

The final topic dealt with road watering as compared with oiling for laying dust. This subject was presented by Mr. Samuel Whinery. For work of each kind equally well done Mr. Whinery estimated that roads can be watered for 3 to 3½ cts. per sq. yd. per season and oiled for 5½ to 6 cts. per oiling. The single oiling will serve about as long as the usual season for watering. He did not believe that the oiling was 50% more efficient than the watering. He pointed out that 6 cts. per sq. yd. per season is the equivalent of capital charges on a form of construction that would be nearly dustless. He suggested that a wise course would be to so construct new roads that they would be dustless and to continue to use water on old roads. Some one suggested, and Mr. Whinery agreed, that oiling at 6 cts. per sq. yd. was possible only at points near where the heavy asphaltic oils are produced or else at the most favored points for receiving shipments.

The time and place of holding the next meeting was, as usual, left to the Board of Directors. The Isthmus of Panama having been mentioned, Mr. F. P. Stearns made some impressive remarks on the wisdom of visiting the canal work in 1911, when it will be in full swing.

SHIPMENTS OF CEMENT TO THE PANAMA CANAL for building the locks have begun. The first shipload of about 25,000 bbls. has just been sent from New York to Panama by the "Tremont." The cement will be landed at Dock No. 1 at Colon, where the slip alongside has been dredged to afford 33 ft. depth of water. Part of the cement will be unloaded into cars for shipment across the Isthmus to the locks at the Pacific end. The remainder will be unloaded into barges which will carry it to the Gatun locks. At Gatun a cement storage shed of 100,000 bbls. capacity is finished, and the machinery for mixing and handling concrete is nearly ready for operation.

Flood Protection in the Kansas River Valley at Kansas City.

By J. Y. OLESEN.*

The Kansas River is the third largest tributary of the Missouri and enters that stream at the state line between Kansas and Missouri. Its total watershed is about 60,000 sq. mi., and the channel near the mouth can carry about 150,000 cu. ft. per sec., without danger of overflow. This would be about 0.1-in. run-off per day from the watershed. It is therefore seen that in an unusually heavy rainfall extending over the greater part of the watershed and continuing for a considerable time the river will overflow its banks.

This has happened three times in the last six years, in 1903, 1904 and 1908. Of the three floods that of 1903 was the greatest; it is estimated that the damage done was $25,000,000. The damage of the flood of 1904 is estimated at $5,000,000, while the flood of 1908, which is supposed to have exceeded the one of 1904 by 15%, did damage to the amount of about $2,000,000. Thus a total of $32,000,000 damage is chargeable to these three floods. The diagram, Fig. 2, gives the heights of other high waters of the last 50 years at Kansas City.

The Kansas River has been encroached upon by riparian owners until its original width of about 540 to 850 ft., as shown by the meander lines of 1856, is reduced to a width of 420 to 590 ft. There are evidences of encroachments all along the river, particularly in the vicinity of the stockyards. Seventeen bridges cross the river within a distance of nine miles, and nearly all of them are low structures with from two to four piers in the river.† They are listed in the table below, which also compares their lengths and elevations with desired width of channel and the 1903 and 1908 flood levels. The profile Fig. 3 shows the relation to the flood levels more graphically. The piers rest on piles cut off a little below low water, and to protect the foundations from scour each pier is surrounded by large quantities of stone. Also, stone dikes have been built out into the stream to prevent erosion. The obstructions caused by the bridges and the encroachments on the channel are said to have diminished the river's carrying capacity by one-half.

The relation of the river to Kansas City is exhibited by the map Fig. 1 herewith. Most of the business of the two cities is in the West Bottoms, and the second greatest stock and packing industry in the United States is located here, on both sides of the Kansas River. The railroads run trains into these bottoms and the Union Station and most of the yards and shops are located here. Therefore when the flood comes it interrupts railway traffic and all business in the packing houses and wholesale establishments.

*U. S. Engineer Office, Kansas City, Mo.

†The 1903 flood wrought great havoc among the bridges. The conditions resulting are pictured in Eng. News, Sept. 17, 1903, pp. 233 to 236.

Several reports on flood prevention have been made, and in the following are given the recommendations of two of them.

ARMY ENGINEERS' REPORT, 1904.—In 1904 a Board of Army Engineers made a report and recommended the following: (1) The banks for a distance of 17,000 ft. above the mouth (to the Fifth Street bridge, No. 13 of map and table), where space is a matter of great importance, to be protected by solid concrete walls 30 ft. high above mean low water, resting on piles driven to bed rock, with suitable protection against flood scour. (2) The width of the river between the tops of the walls to be 734 ft. (3) The bed of the river to be dredged free of all solid obstructions, so that it shall be occupied only by the natural alluvium carried by the stream, which yields readily to scour under high velocities of flow. This work to be carried to at least 15 ft. below low water. (4) All bridges to be limited to two river piers 300 ft. apart c. to c. measured at right angles to the channel; these piers to be carried down to rock; the lowest point of the trusses to be as high as the hydraulic grade line deduced for a flood like that of 1903 in a channel of the assumed section. (5) Above the Fifth Street bridge earthen embankments to be used; these to be given sufficient height and distance apart to carry the flood flow of the river, and to be protected by heavy riprap. (6) A levee and bank revetment to be carried along the right bank of the Missouri from the mouth of the Kaw to the bluffs above Hannibal Bridge. (7) Turkey Creek to be brought out direct to the river from a point a short distance above the pumping station, and to be leveed back to a point where the flood plane of the regulated river cuts the banks.

The river over the length considered has a uniform slope of 1.5 ft. per mile, and with a section as proposed it would have a mean velocity of 10 to 13 ft. per sec. at extreme flood stage. This velocity in a river composed of soft alluvium like that of the Missouri and Kaw rivers would produce a heavy scour, and the Board assumed this scour to extend to an average depth of 15 ft. below low water, which would be 7 to 8 ft. below the bed. The resulting section would have an area of nearly 32,000 sq. ft., exclusive of bridge piers.

The total cost of this work was estimated at about $10,500,000. Of this amount about $4,200,000 was for the protection of the bottoms on the right bank of the river below Fifth Street bridge; $4,800,000 for the bottoms on the left bank of the river, known as Armourdale, and $1,500,000 for protection up to Argentine and the bottoms above.

The Board also recommended that perhaps the best solution of the problem would be to make a new channel for the river, commencing near the mouth of Mattoon Creek and following the bluffs of the left bank to the point where the present channel strikes them above the James Street bridge (No. 4).

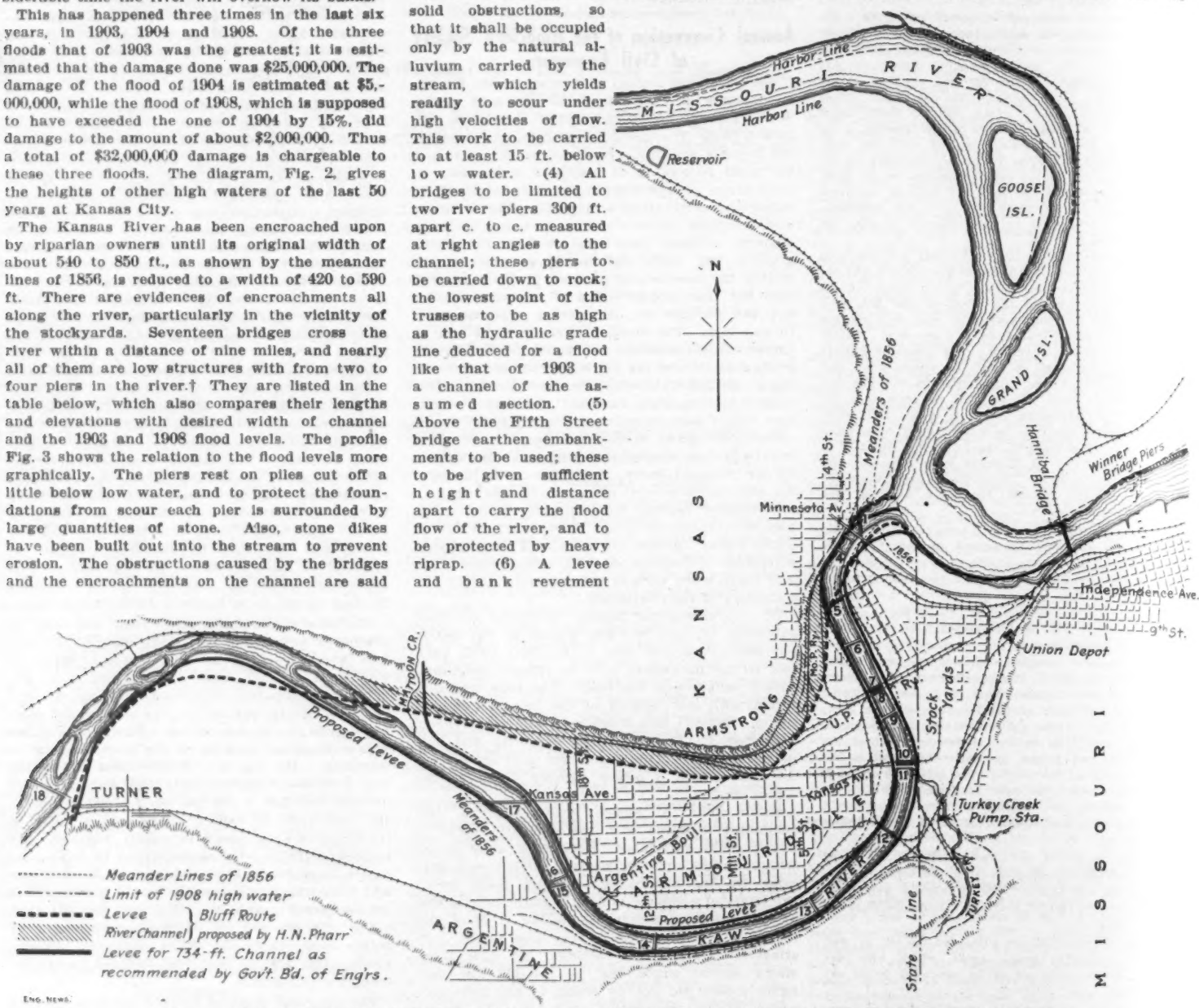


FIG. 1. MAP OF KANSAS RIVER IN VICINITY OF KANSAS CITY, SHOWING FLOOD PROTECTION PROJECTS.

THE KAW VALLEY DRAINAGE DISTRICT.—After the flood of 1903 the Kaw Valley Drainage District was organized under a statute of the State of Kansas, and this organization now has control over the Kansas River for seven miles above its mouth.

The statute was enacted after the flood of 1903. It grants exclusive jurisdiction and control over all natural water courses to certain public corporations known as "Drainage Districts." The act seems to confer extensive powers. Such Drainage Districts are authorized to widen and deepen the channels, to construct levees along the banks, to change the course by abandoning the old channels and making new ones, and to

fill up and sell the old abandoned channels. They are given authority to appropriate by condemnation proceedings all land necessary for widening or establishing a new channel, or for levees, or any other purposes; and they are given the right to take possession as soon as the land is condemned, notwithstanding any appeal prosecuted by the land owner, the only question to be tried on any appeal being the value of the land and the amount of damages that the land owner may be

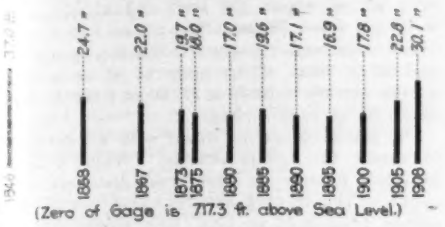


Fig. 2. Flood Heights of Missouri River at Hannibal Bridge, Kansas City, Mo.

entitled to. The Drainage District on any such appeal may contest the title of the land owner and show, if it can, that the land claimed by him has been made by wrongful filling in or encroachment upon the channel of the river. To pay for such improvements the Drainage Districts are authorized to issue bonds for all improvements that benefit the lands of the entire district, and to levy special assessments upon the lands benefited by improvements which confer only local protection.

The Kaw Valley Drainage District adopted a plan to improve the river by widening it to a width of 734 ft. from the Fifth Street bridge to the Union Pacific R. R. bridge (Bridges 13 and 8, in the map), and by removing the obstructions from the channel and building levees along the banks. No provision was made to widen the river from the Union Pacific bridge to the mouth, although the river below this bridge in some places is narrower than above it. To do this work the Board voted to issue $550,000 in bonds.

Immediately after the bonds were voted, several railroad companies whose tracks, bridges and rights of way would be appropriated or affected thereby, brought suit to stop the making of the proposed improvements and the issuing of the bonds, on the ground, among others, that the widening of the short reach of the river between the said bridges was merely local and would only protect Armourdale and the lands adjacent to such improvements and would give no protection to the West Bottoms or the lands situated along the river below the Union Pacific bridge. It was argued that the bonds could not be lawfully issued unless the improvement would protect from overflow the property of all taxpayers in the district who were required to contribute to the payment of such bonds, and that the improvement proposed would be useless, since no provision was made for the widening or improvement of the river from the Union Pacific bridge to the mouth, which was the narrowest part.

These suits by the railroads were followed by similar ones brought by the Stock Yards Company and other corporations, and resulted in a decree of the United States Court granting a perpetual injunction against widening the river beyond 600 ft. and against the issuing of the $350,000 in bonds voted for that purpose, but authorizing the issuing of the $200,000 of bonds voted for cleaning out the channel and building levees.

The Drainage District officers refused to make the improvements authorized by the decree of the court, but appealed to a higher court, where the litigation is now pending. Recently they have changed their attitude, however, as noted further on.

H. N. PHARR'S REPORT.—During the flood of 1908, the Mayor of Kansas City, Mo., invited the Mayor of Kansas City, Kans., to join him in a call for a flood congress to discuss the flood and possible remedies. At the meeting the members of the Real Estate Exchange of Kansas City presented a report made to them by D. W. Pike, C. E., and a Committee on Engineering was appointed, which engaged Mr. H. N. Pharr, of Memphis, Tenn., an authority on floods and levees, to investigate conditions and suggest remedies.

Mr. Pharr's report recommended that the channel of the Kaw be shifted to a location along the bluffs of the left bank from Mattoon Creek to the mouth. This is in substance the scheme that had been suggested by the Army Engineers' Board as the best solution of the problem.

Mr. Pharr set forth all essential details of the project and the method of construction. The new location was to be protected by a wide levee on the side away from the bluff, forming a channel 610 ft. wide on bottom with side slopes of 1½ to 1 on the bluff side and 3 to 1 on the levee side. The new slope of the river would be about 2½ ft. per mile, as against 1½ ft. for the present channel. At the mouth a levee was to be built eastward from the mouth of the Kaw along the right bank of the Missouri to the bluffs just above Hannibal Bridge. Turkey Creek was to be carried to the new channel by a concrete arch culvert 22 × 30 ft. extending back to a point above maximum flood level, so that in high water it would discharge into the river under a head. Pump wells for surface drainage were provided in the plan, from which the run-off water was to be pumped over the levee in flood time.

Some of the advantages of the diversion project over the regulation scheme are stated as follows:

The cost will be about the same if bridges and all damages are considered by both routes.

The high levees on the present channel location would interfere with the railroad and street grades, and would not on the location near the bluff. The necessary right of way on the present channel location to widen the channel to 734 ft., as required, cannot be obtained without greatly injuring, and possibly destroying, some of the most important industries in the valley, while a less serious difficulty in this respect is met on the bluff route.

The safest, best and most permanent channel and levees can be constructed on the bluff route, because the bluffs on the north side will serve as a levee, and sufficient right of way can be provided on the south side to build an earth levee of adequate proportion.

The reconstruction and maintenance of a great many bridges would be avoided, and better facilities would be furnished.

There are so many and varied interests injured, and that will have to be rearranged on the present channel location, that it is extremely doubtful if a satisfactory solution of the problem can be worked out on that route, and each year makes and will continue to make the situation more complicated. On the bluff route there is no interest in the way that should prove a serious obstacle.

The relation of the proposed location to the present channel may be understood better through a glance at Fig. 4, a typical cross-section of the valley.

The total cost of the diversion was estimated at about $14,250,000, after deducting a credit for sale of old channel about equal to the cost of the new right-of-way. The time required for construction was set at three years. The annual maintenance cost, including levee maintenance and cost of pumping, was estimated at $25,000.

PRESENT ACTION.—However, since the organization of the Drainage District the regulation scheme has remained in the foreground, and the District has recently accepted the court decision so far as to put up for sale the $200,000 of bonds found valid. Work is already started on levee construction. Contracts have been let for levees extending from Fifth St. bridge (No. 13) to a point well above 18th St., on the right bank, and along the front of Argentine on the left bank.

The District has retained Capt. E. H. Schulz, Corps of Engineers, U. S. Army, as consulting engineer, and intends to follow in substance the U. S. Board of Engineers' report of 1904. It wants all bridges raised to the hydraulic grade line deduced for a flood like that of 1903, and a channel width of 734 ft. between the river edges of levee at the top. The levee along both sides of the river is to be earth and 30 ft. wide at the top.

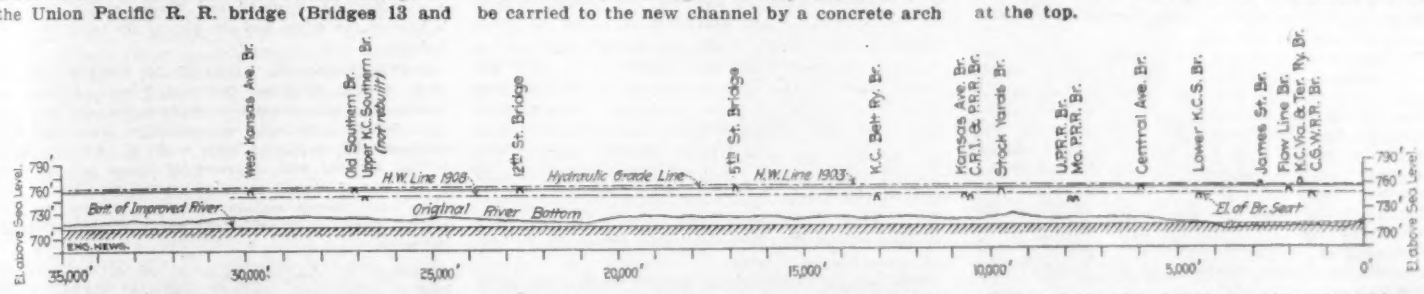


FIG. 3. PROFILE OF KANSAS RIVER THROUGH KANSAS CITY, SHOWING RELATIVE ELEVATIONS OF FLOOD LEVELS AND BRIDGES.

The total cost of constructing the levees is estimated at $1,183,000. The change required in railways, bridges, etc., along the Drainage District's harbor line or line of levee are briefly as follows:

On the left (west) bank of the Kansas River below the Kansas City Southern Railroad bridge the harbor line is located so as not to interfere with the railroads or other improvements except that the levee height will require the railroad tracks to be raised to a corresponding elevation. The levee must connect with the bluffs some 1,200 ft. from the James St. bridge in order that the Missouri Pacific tracks may pass under the James St. bridge. On the right (east) bank, the Chicago Great Western bridge will have to be extended to the harbor line. Both the Chicago Great Western and the old Wyandotte & Northwestern enter the present bridge upon curved tracks. The alinement of the old Wyandotte & Northwestern track will need to be changed from James St. north. Land of the Metropolitan Water Co., including the present building, will be taken. At James St. and south, the tankhouse, stocksheds and unloading decks of the Fowler Packing Co. are taken, together with the side track west of same. The driveway north and

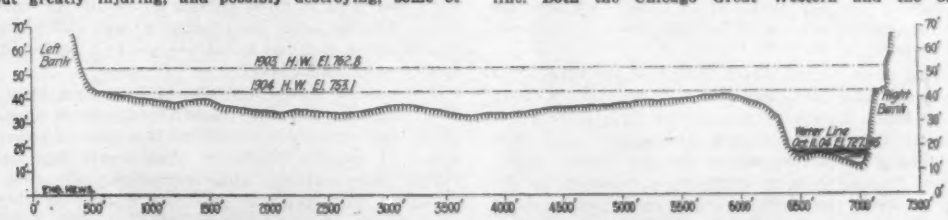


FIG. 4. A TYPICAL CROSS-SECTION OF THE KANSAS RIVER VALLEY.

Section at Mill Street, Armourdale.

Waterway, 1903:		Waterway, 1904:	
In channel	33,932 sq. ft.	In channel	21,163
Outside	80,156	Outside	25,160
Total	114,088	Total	46,323

TABLE OF KANSAS RIVER BRIDGES AT KANSAS CITY, KAN.

No, From Mouth.	Name of Bridge.	No. of Spans.	Total length, ft	Approx. elevation lowest point, ft.	Must be raised to bring up to hydr. grade, ft.	Must be lengthened to give 734-ft. channel, ft.	Elev. of 1903 flood, ft.	Elev. of 1908 flood, ft.
1.	Chicago Great Western R. R.	3	610.5	752.1	1.0	124	754.1	749.4
2.	K. C. Via. & Ter. R. R. Co.	2	608.8	767.1	..	...	753.3	749.4
3.	K. C. M. Flow Line	2	460.0	752.3	1.0	325	754.1	749.4
4.	James Street	2	493.0	760.7	..	241	756.2	749.5
5.	Lower K. C. Southern	3	592.5	747.6	6.4	142	757.1	751.2
6.	Central Avenue	3	600.0	757.3	..	134	757.7	750.8
7.	Missouri Pacific R. R.	3	561.0	746.2	8.7	173	758.7	752.2
8.	Union Pacific R. R.	3	561.0	744.2	10.7	173	758.8	752.2
9.	Stock Yards	3	510.0	755.5	..	224	760.4	751.5
10.	C. R. I. & Pac. R. R.	2	604.0	749.8	5.9	130	761.6	753.4
11.	Kansas Avenue	3	561.0	750.2	5.6	173	761.7	753.5
12.	K. C. Belt Ry.	2	600.0	751.6	4.7	134	762.2	753.5
13.	Fifth Street	3	600.0	761.8	..	134	762.8	753.8
14.	Twelfth Street	3	600.0	762.1	..	134	764.0	754.8
15.	Upper K. C. Southern (not rebuilt)	4	636.0	....	..	98	765.2	....
16.	Old Southern	4	640.0	763.3	..	94	765.2	755.6
17.	West Kansas Ave.	6	1,201.7	764.7	..	...	765.7	755.8

tunnel under James St. are cut off. The levee height is 3.2 ft. below top of rail of Chicago Great Western Railway; is about grade where it crosses James St.; is 7 to 9 ft. above the surface of the low ground between James St. and the Kansas City Southern bridge, and is about 1.5 ft. above track of the Kansas City Southern Railway. The Kansas City Southern bridge will need to be rebuilt and raised and lengthened, and the tracks and connections approaching it will have to be raised accordingly.

Central Avenue bridge will need to be extended and approaches modified. The Missouri Pacific bridge and Union Pacific bridge will have to be raised and extended and the piers and abutments reconstructed and the grades of approach tracks raised accordingly. The same is true of the Kansas City Southern. On the left bank several small property owners north of Central Ave. will lose their holdings. The Kansas City Southern trestle will need to be reconstructed and the alinement changed for about 1,000 ft. below the Union Pacific bridge. The alinement and grades of the Kansas City Southern will have to be changed all the way. The levee will encroach on the Nelson Morris Packing Co.'s ground, though perhaps not seriously.

The stock yards bridge is high enough, but will need to be extended. The Chicago, Rock Island & Pacific bridge will need to be raised and extended; the Kansas Avenue bridge reconstructed and extended with new piers. On the left bank the Kansas City Southern railway will have to be moved to the new harbor line and rebuilt. The stock yards will lose much land and the viaduct and piers be reconstructed. On the right bank the levee height is several feet above the general surface at the stock yards bridge; the tracks and decks will need to be raised and their alinement considerably modified as they approach the Kansas Avenue and the Union Pacific bridges.

The Kansas City Belt Railway bridge will need to be raised and extended on west end. On right (east) bank the two main tracks leading to stock yards will have to be moved east the most of the way. Some sidetracks will be cut out. The general level of the tracks will be raised about 3 ft. On the left (west) bank the changes to be made are not serious, except provision should be made for the stock yards viaduct. The Kansas City Southern Railroad will have to be raised and the alinement changed. The Atchison, Topeka & Santa Fe and the stock yards track and connections are slightly affected in the vicinity of the Rex mills. On the left bank the changes are not serious except for a short distance along the Schwarzschild & Sulzberger plant and to the driveway of the stock yards. The approach to the Fifth St. bridge will have to be raised. The grade and alinement of the Kansas City Southern will be changed.

In general it is proposed that railroad tracks shall be permitted to occupy the top of the levee at the elevation of the established grade of the same wherever the present location of the same requires it.

The most recent development is an agreement between the Drainage District and the Kansas City Stock Yards Co. for ending all litigation between these parties and arranging a channel widening project based on the full 734-ft. width from Central Ave. to Fifth St. (bridges 6 to 13). It involves the exchange of lands, cessation of suits, vacating injunctions, payment of $100,000 in District bonds to the Stock Yards Company, and future continuance of the widening to the mouth of the river. Under this plan the Kansas City Southern Ry. is to be shifted to the top of the levee.

A VERY LARGE PIER has just been completed in Boston, Mass., harbor by the Boston & Albany R. R. as one of a number which are to replace the piers destroyed in the big fire of July 8, 1908. The pier just completed, to be used by the Cunard Line for their Boston landing place, is 780 ft. long and 240 ft. wide.

An Electric-Driven Driller for Making Deep Blast Holes.*

Some demand has been made on manufacturers for a portable, blast-hole, drilling machine operated by an electric motor instead of a boiler and engine. Usually where blasting operations are conducted within city limits some inconvenience and a large item of expense are represented in providing a licensed engineer, as required by law, for each separate steam-driven machine. Indeed, in some locations, it is impossible to use a boiler at the driller. Some contractors have operated a series of machines from one central boiler by carrying out steam lines. Others have used compressed air similarly, for instance, in the extensive blasting operations on the "Low Grade" cut-off of the Pennsylvania R. R. between Philadelphia and Altoona, Pa. The motor-driven drill was designed to obviate the disadvantages of the steam or air machines as used in such cases, when a boiler could not be employed.

Such an electric-driven driller has recently been tried at the James and A. C. O'Laughlin quarry at Belwood, near Chicago. A standard type and size of driller was used, without boiler or engine. A back-geared 10-HP. motor was placed over the rear truck of the machine and the flywheel was belted to the drilling mechanism. This latter was back geared to the shaft of the driven flywheel and was balanced to run as smoothly as possible.

The motor controller is placed on the front of the machine, at the drill operator's hand and near the other levers which control the drilling operations. One man can easily handle the machine without assistance, except when pumping sand or moving to a new bore hole. The laying of feed wires and motor adjustments is looked after by an electrician in charge, where there are several machines in use.

Generally, the machine is used for loading the holes. For this service, the regular drilling bit is removed and a wooden rammer is placed on the drill stem. After five to eight sticks of dynamite have been dropped into the hole, the ramming tool is lowered after them, forcing them into a compact mass at the bottom. The tools are then withdrawn and the process repeated until the hole is filled within 25 ft. of the surface. At this point the exploding caps and wires are inserted and the holes are packed, by hand, full of sand and gravel.

Best results have been obtained in deep blast-hole drilling with the 5⅝-in. drill. It is more easily and cheaply drilled than is a hole of either larger or smaller diameter. The larger hole involves more cutting while permitting no corresponding advantage in size and weight of drill bar; the heaviest practicable tools can be operated in the 5⅝-in. hole. A smaller hole necessitates a reduction, in the diameter and weight of the stem and bit, which detracts from their efficiency.

The machine at the O'Loughlin quarry has been successful in all ways. During its first hour of use 9 ft. of 5⅝-in. hole was drilled in fairly hard limestone in an hour. The normal rate of drilling is 5 ft. per hour, including all stops. At the full speed of the motor the drilling tools drop about 60 times per minute, which is ample in all cases to obtain the maximum drilling speed. As the hole becomes deeper or clogged with cuttings, before and pumping, the rapidity of the stroke is gradually reduced, to say, 50 per minute, in order that the cutting bit may deliver its blow with best effect. This can be done by reducing the speed of the motor.

The drilling tools, used in the case mentioned, comprised a stem weighing about 1,000 lbs., a drill bit of about 150 lbs., and a rope socket weighing some 50 lbs. The bit as stated gives a 5⅝-in. hole and the stem is 3¾ ins. in diameter and 22 ft. long. With a stroke of 30 or 35 ins. a blow having a force of 3,000 to 3,500 ft. lbs. is obtained at each stroke.

The machine can be made with a traction attachment for self-propulsion. While it is impractical to move it over great distances on account of the trailing electric cable, yet for short moves from hole to hole, this attachment is a great convenience.

The driller which has been here described was built by the Keystone Driller Co., of Beaver Falls, Pa.

*From information furnished by the Keystone Driller Co., Beaver Falls, Pa.

Protection of Life in European Coal Mines.*

By J. W. PAUL, Mining Engineer.†

For the work of rescuing miners and combatting fires underground, many of the fire-brigade stations maintained at European mines are equipped with rescue apparatus and men are trained in its use. In Austria a law requires that each mine shall be equipped with rescue apparatus and that at all times a certain percentage of the underground employees shall be trained in the proper use of the same. In France and Belgium similar laws are about to go into effect. In Germany, England, Scotland and Wales, rescue apparatus is kept at the mines and the miners are being regularly trained.

RESTRICTIONS IN THE USE OF EXPLOSIVES.—In Great Britain, Belgium, Germany, France, Austria and Russia, the mine-inspection departments, the operators and the manufacturers of explosives have for their guidance the results of tests made at their explosive-testing stations and operators of mines are restricted to the use of certain types of explosives; while in Belgium and Austria certain classes of miners are prohibited from using explosives for any purpose within the mine.

COAL-DUST EXPLOSIONS.—At all of the European mining experiment stations coal-dust explosions are produced without the admixture of explosive gas. However, none of the experimenters have as yet arrived at an acceptable explanation of the phenomenon of a coal-dust explosion. In those mines in which explosives are used for blasting, much attention is given to the presence of coal dust and the moisture of that part of the mine in which the shot is to be fired. Watering the workings of the mine by specially constructed cars, by hose and nozzle and by spraying devices is practiced systematically. Much faith appears to be entertained in the wetting of the floor and sides within a certain minimum radius of the point at which an explosive is to be fired.

SAFETY LAMPS.—In England the lamps are carefully inspected before being taken into the pit and likewise at the bottom of the pit by a mine official. To set a safety lamp on its bottom in any part of the mine is forbidden. When a workman wishes to place his lamp to one side, he must hang it in a safe position. In Belgium the lamps are inspected by an official on the outside of the mine to see that all of its parts are properly assembled, no test being made of the lamp to determine if it is defective. In Germany the lamps are cleaned and locked and handed to the miners who examine them to ascertain if they are in a condition suitable for use. All safety lamps in that country are without bonnets to enable the miner to observe the condition of the gauze.

RETREATING CHAMBER.—The Nordbahn mine at Maehrisch-Austrau is provided with a retreating chamber capable of accommodating 300 men. This station is about a mile from the bottom of the shaft, and is so arranged that it may be closed with heavy air-tight doors. Food, water, ventilation, light, telephone, rescue apparatus and medicines are provided. In case of a fire or an explosion which might prevent the escape of the miners to the surface, they may retire to the chamber and remain there until rescued. With the apparatus

*Extracts from an address delivered before the Coal Mining Institute of America, at Punxsutawney, Pa., June 29, 1909.

†In charge of Mine Lighting Investigations and Rescue Work, Technologic Branch, U. S. Geological Survey.

provided in this underground station, the men may do much effective work in combatting the fire and in aiding their fellow miners who may be in irrespirable air and unable without assistance to reach the retreating chamber. This provision is another evidence of the aggressive efforts being made to further reduce loss of life in European coal mines.

AN EXPLOSION IN THE MAKEWSKA MINE in the Don River district of Russia, July 11, killed 14 of the miners. There were 150 miners in the workings at the time of the explosion.

A PASSENGER TRAIN IN HAYTI was wrecked July 4 near Beaudet by colliding with a freight. Ten of the soldiers who were on the passenger train as a guard for President Simon were killed. The President was not hurt but directed the work of caring for the injured and clearing away the wreckage.

A TORNADO IN MINNESOTA July 11 demolished a number of buildings at Ortonville and Bigstone,' near the western boundary of the state. Nine persons were killed and about 100 others were injured.

A wind storm at Xenia, Clay Co., Ill., on the same date wrecked a dozen or more residence buildings.

FLOODS IN THE MISSOURI VALLEY resulted from an abnormally heavy rainfall July 7 and caused a great amount of damage at various places in Missouri, Iowa and Kansas. A passenger train was derailed near Pomona, Kan., while attempting to traverse a flooded stretch of track on the Atchison, Topeka & Santa Fe Ry. Four of the ten coaches rolled over into 18 ft. of water. The cars overturned slowly, however, so that the passengers and crew had time to escape into the Pullman cars at the rear of the train and were eventually rescued by boats and rafts from nearby farmhouses.

Pattonsburg, Mo., suffered heavily, as many of its streets were flooded to a depth of 10 ft., and hundreds of persons at this place were marooned on roofs and in second stories until taken to higher land by row-boats. At Chillicothe, Mo., large areas were flooded and hundreds of the inhabitants were obliged to leave their homes. Practically all railways to the north and west from St. Joseph, Mo., were blocked by the floods and traffic was similarly obstructed at a number of smaller towns. Reports of July 10 announce continued heavy rainfall with the waters of the Missouri and Mississippi Rivers still rising.

AN EXPLOSION IN THE COAL BUNKERS of the U. S. cruiser "North Carolina" in Santa Lucia Harbor, near Naples, Italy, July 11, killed one man and injured several others of her crew. Reports state that the man killed, an ensign, was making an investigation to learn if gas had been generated by the 300 tons of coal in the ship's bunkers. He was accompanied by several sailors, one of whom carried a lighted candle which caused the explosion.

SEVERAL OLD WOODEN BRIDGES WERE wrecked in the last two weeks.

The Troy Bridge over the Hudson River between Waterford and Lansingburgh, near Troy, N. Y., was destroyed by fire on July 10. Leakage current from an electric wire is supposed to have started the fire. The fire progressed very fast from the start. The bridge was built in 1804 by the noted Theodore Burr. It had been strengthened a few years ago to carry trolley cars. It was roofed over, as is the case with many of the old timber highway bridges. A toll company owned the structure. The bridge comprised four spans of about 200 ft. each. It was probably the oldest remaining timber truss bridge in the country.

A wooden railroad bridge over the Merrimack River at Nashua, N. H., burned in the night of June 26-27. This bridge was built in 1874. It consisted of three Howe spans about 150 ft. each. It carried the track of the Portland Division of the Boston & Maine Ry., this portion being formerly the Nashua & Rochester.

A wooden highway bridge over the Des Moines River near Pella, Iowa, was undermined and wrecked by high water in the last week of June. It was a covered structure, built about 1875.

TWO LAKE FREIGHT STEAMERS collided July 12 in Lake Superior about 1½ miles off Whitefish Point Lighthouse, near Sault Ste. Marie, Mich. The "Isaac M. Scott" crashed into the side of the "John B. Cowle" penetrating a distance of about 15 ft. The "Cowle," a steel vessel 445 ft. long with 50-ft. beam, was loaded with 8,000 tons of iron ore and sank in 50 fathoms of water three minutes after the collision. Fourteen members of the "Cowle's" crew were drowned. The "Isaac M. Scott," which was also a steel vessel, was seriously damaged at the bow, but as she was not loaded was in no danger of sinking and reached port safely at Sault Ste. Marie.

AN AEROPLANE FLIGHT of 25 miles, straightaway, was made by M. Bleriot between Etampes and Chevilly, France, on July 13. The distance is reported to have been covered in 56 min., 10 sec., including a stop of eleven minutes for adjustments. This gives a speed of flight of about 35 mi. per hr., which is considered low for an aeroplane. This flight was made in preparation for an attempt to cross the English Channel. A prize of $2,800, offered by the French Aero Club for a cross-country flight, was awarded to Mr. Bleriot.

On July 13, Mr. G. H. Curtis made a two-mile circular flight on Long Island, near New York City. This is the first of a series of flights in preparation for the international race at Rheims, France, on Aug. 28. The time of this flight is reported as 2 min., 26 sec., which gives an average speed of 49.4 mi. per hr.

The Wright Brothers, of Dayton, Ohio, have been making short flights at Fort Meyer, Va., in preparation for the acceptance trials of an aeroplane which they are under contract to deliver to the Army Signal Corps. Various minor difficulties have been reported so that no sustained flights like those on the same ground a year ago have been attempted.

THE NEW BUILDING CODE FOR NEW YORK CITY was passed by the Board of Aldermen on July 13 by the very close vote of 40 for and 38 against. It has now to go to the Mayor for approval or veto, and if no action is taken by him within ten days it becomes a law automatically. Two codes, one drawn by a majority and one by a minority of the commission appointed for the purpose, were submitted and the majority report, with minor alterations, was the one finally adopted by the aldermen.

A SOFT-ROCK TUNNELING RECORD has been made in Fernando Tunnel of the Los Angeles Aqueduct, where in May, 1909, the north heading advanced 579 ft. This was in soft sandstone. The tools used were hand augers or hand rock-drilling steels and hammers. The tunnel is 11½ ft. by 11½ ft. The explosive was 40% ammonia dynamite, of which some 9 lbs. per lin. ft. was required. The mechanical equipment comprises Roots positive blowers, an electric lighting system, and electric locomotives hauling rocker dump-cars. The men worked in three 8-hr. shifts. The record run noted was made under a bonus system of payment for labor, involving payment of 25 cts. per man for every foot of advance exceeding 3.5 ft. per shift. "The men entered into the spirit of the contest practically as athletes enter into a game, each one putting forth his best efforts," is the engineer's report as to the result. The tunnel is part of the Saugus Division of the Aqueduct, in charge of Mr. D. L. Reaburn, Asst. Engr. Mr. Wm. Mulholland is Chief Engineer of the entire work, and Mr. J. B. Lippincott is Assistant Chief Engineer.

The record above noted is far in advance of any figure of monthly heading advance ever made in America, except a run of 808 ft. in shale in the recently completed Gunnison Tunnel. In this latter, however, electrically driven augers were used.

ANOTHER SUBWAY PROPOSITION FOR NEW York has been made to the Public Service Commission by the Interborough Rapid Transit Co., which operates the present New York subways and the Manhattan Elevated lines. The present proposition is an amendment to one offered some months ago, which latter was not satisfactory to the Commission. The offer includes a new four-track west side subway south of 42d St., a two-track subway and bridge connection from the present subway to Nevins St., Brooklyn, over the Manhattan Bridge, a two-track subway from about 36th St. and Park Ave., under Third Ave. to the present subway at 149th St. and Lenox Ave., a two-track local subway under Lexington Ave. to the Harlem River, an extension of the present west side elevated to 194th St., the third-tracking of the Ninth Ave. elevated below 14th St., the third-tracking of the Second and Third Ave. elevated, a spur over the Queensboro Bridge and the sale of the Steinway Tunnel to the city with a 5-ct. fare from the east end of the tunnel to any part of the Interborough's subways in Manhattan.

The proposition is made pursuant to the recent amendment to the Rapid Transit Act embodying the indeterminate franchise principle. The franchise shall be fixed to cover the amortization period of securities issued and the city and the company shall decide upon the length of ownership by the company, provided that the city has a right to buy after ten years.

PANAMA CANAL EXCAVATION during June was 2,895,793 cu. yds. place measurement, a daily average of 111,377 cu. yds. for the 26 working days, as against 2,896,095 cu. yds., a daily average of 115,844 cu. yds. for the 25 working days in May. The rainfall in June was 11.85 ins. and in May 9.82 ins. During June there were laid 13,605 cu. yds. of concrete and 425,924 cu. yds. of fill were placed in dams, both increases over the previous month.

RUNNING SPECIAL CARS FOR WOMEN PASSENGERS, which was inaugurated on the Hudson Tunnel Ry., N. Y. City, in April last, has now been abandoned, after three months' trial. It was found that only a small percentage of women preferred to ride in the special car at the rear of the train reserved for their use.

THE NEW "CLERMONT" WAS LAUNCHED July 10 at Mariners' Harbor, Staten Island, N. Y. She was built as an exact duplicate of Robert Fulton's original "Clermont" and is intended to take part in the naval parade up the Hudson which will be held Oct. 1, in connection with the Hudson-Fulton celebration. The new boat was designed in accordance with the few plans and contemporary descriptions of the original that are still in existence. She is 150 ft. long with 18-ft. beam and a depth of 7 ft., and draws only 2 ft. of water. Her bottom is flat without a keel and her sides are nearly perpendicular from end to end, the width at the bottom being only about 2 ft. less than at the deck. Both ends of the hull are pointed, so that they include an angle of about 60°, and no effort is made to modify the abrupt angle where the 60° lines of the prow and stern join the parallel sides. A plain wooden railing encloses the deck and near each end of the boat is a small cabin projecting above the deck about 2 ft. Two slender masts rise about 20 ft. above the deck. None of the machinery had been installed at the time of the launching.

The launching ceremony was somewhat marred by the difficulty in starting the boat down the ways. She rested in a flat rectangular cradle with shoes apparently continuous from end to end, no special support being provided for the bow or stern. After the timbers tying the cradle to the ways had been sawn through, the boat showed no tendency to move and it was necessary to employ a locomotive crane to shove her off. The crane was brought up on a track whose center line was practically a continuation of that of the boat and was advanced until its boom extended across the platform on which was the christening party and touched the prow. The crane was then backed off a few feet and then brought up again quickly so that the boom delivered a blow against the prow of the boat, which moved a few inches down the ways. Two or three times more, the crane bunted the prow, and the "Clermont" on her cradle was moved about five feet along the ways so that it was no longer possible for the boom to reach her without jeopardizing the safety of the christening party's platform. The boat continued to move down the ways but so slowly that her motion was barely perceptible. At this juncture a number of men climbed up and by pushing against the prow assisted in maintaining the motion until, when nearly half her slide was completed, and the unit pressure on that part of the shoes remaining on the ways was increased by the lifting of her stern in the water, she began to move more rapidly and finished the descent unassisted.

The new "Clermont's" sponsor was Mrs. Alice C. Sutcliffe, great-grand-daughter of Robert Fulton, and the liquid used for the christening was water from the well on the Livingston estate at Clermont, N. Y. One feature of the ceremonies was the ringing of five bells (2.30 o'clock) on the ship's bell of the original "Clermont." The bell was loaned for the occasion by the Albany Day Line. The christening was done at the first movement of the boat under the action of the crane, and at the same time carrier pigeons were released from a basket at the prow of the boat and started their flight, presumably for Clermont, N. Y.

THE NEW YORK BARGE CANAL "Bulletin" for June gives the total value of work done during May as amounting to $590,230. The total amount of work now completed represents a total outlay of $10,474,448. The total contracts now in force amount to $36,544,877, and nine additional pieces of work are now ready to be let, the aggregate estimated cost being $10,553,154.

AN OCEAN BOULEVARD along the New Jersey coast all the way from Atlantic Highlands to Cape May is planned by the New Jersey State Highway Commission. Of the total distance of 126 miles, more than four-fifths is already completed. It is proposed to raise part of the cost of completing and maintaining the road by increasing the automobile license fees.

A NEW PASSENGER STATION for Chicago is proposed by the Chicago & Western Indiana Ry., whose terminal at Polk and Dearborn Sts. is used by several railways. The company has been purchasing land for some time, and has two general plans in view. One plan provides for a station on the present site, but extending from Clark St. to State St. The other provides for a passenger station at 12th St., and a 12-story freight station and warehouse on the site of the present passenger terminal. In either case the tracks (now on the street level) would be elevated, and there would be 16 tracks in the trainshed, while the head-house would be a 14-story structure for railway offices, etc. The plans are only tentative, and it is stated that definite adoption of any plan may not be made for a year or

more. In connection with the 12th St. site, the plan proposed by Mr. F. A. Delano, M. Am. Soc. C. E., President of the Wabash Ry., for a series of railway terminal stations fronting on this street, has been revived. This plan was described in our issue of Feb. 16, 1905.

THE GREATEST SALE OF SCRAP IRON ever held will soon occur at Panama. The "Canal Record" of June 30 states that the old French rolling stock and machinery, which is lying in great heaps all the way across the Isthmus, is to be sold under competitive bids. The French spent nearly $30,000,000 upon their plant for excavating the canal and it is estimated that there are 80,000 to 100,000 tons which may be reclaimed. Much of the material is very badly rusted and the cost of cutting it up for transport will be considerable. The amount is so large; however, that machinery can be installed and with the revival of the steel industry and consequent active demand for scrap, there would seem to be an opportunity for good profits.

GOLDFIELD, the famous Nevada mining camp, was deprived of the electric power, on which it relies for running its mills and stamps, during the day of June 26. A diversion dam of the Nevada-California Power Co., on Bishop Creek, Cal., gave way under excessive head of water caused by melting snows in the Sierra Nevada Mountains. So much debris was carried down stream that ditches leading to pipe lines were filled. In Goldfield the loss for the one day is estimated at about $53,000. This includes the wages of some 1,800 men and the production of nine of the largest mines.

THE CUNARD LINER "MAURETANIA" is reported to have lowered the westward transatlantic record over the long course by 17 minutes on the trip ending at New York, July 8. The record between Daunt's Rock and the Sandy Hook lightship now is 4 days, 16 hrs., 53 min. The average speed record for the trip is thus raised from 25.62 knots (29.46 miles) to 25.70 knots (29.55 miles).

TRAINS WERE HELD UP BY CATERPILLARS in New Brunswick recently, according to "The Sun," of St. John, N. B. The Forest Tent caterpillars infested a section extending about 25 miles between Fredericton Junc. and McAdam Junc., on the Canadian Pacific Ry., where they stripped trees of their foliage over large areas. At night multitudes of the caterpillars attached themselves to the rails, apparently for warmth, and their crushed bodies greased the rails and stopped trains. A jet of steam rigged to play on the rail in front of the truck wheel effectually solved the difficulty.

THE NEW GALVESTON CAUSEWAY, which is to connect the mainland of Texas with the island on which is situated the city of Galveston, has been designed by the Concrete-Steel Engineering Co., New York, and the contracts for construction let. It consists of twenty-eight 70-ft. concrete arches, a 100-ft. steel lift bridge and 8,170 ft. of earth-filled roadway; the total length is 10,642 ft. The contracts for the concrete arches and the fill have been let to the A. M. Blodgett Construction Co., Kansas City, Mo., for $655,000 and $577,000, respectively, and the contract for the steel lift bridge to the Penn Bridge Co., Beaver Falls, Pa., for $97,400. This latter figure is not exact as some details of the design have not finally been decided upon.

MUNICIPAL OWNERSHIP OF A STREET RAILWAY line on Geary St., San Francisco, was defeated by popular vote on June 24. A heavy majority of the votes cast were in favor of the railway, but under the city charter bond-issue proposals have to be approved by two-thirds of the voters who cast their ballot on a given proposition. The total number of votes cast in this case was 22,230, of which 14,425 were for and 7,805 against; the bonds thus lack 395 of the required number of votes. This is the third time that a proposition for a municipal railway in San Francisco has been defeated at the polls. No detailed information is at hand regarding the actual merits of the case.

HIGH WATER IN THE RIVERS OF THE WEST have kept on the alert the engineers in charge of a number of the irrigation projects of the U. S. Reclamation Service. From a statement issued by the Service on July 8, we take the following extracts:

The rivers of the West all seem to be on a rampage, and from every section comes reports of the "largest recorded history of stream flow." The engineers of the Reclamation Service have been anxiously watching the gages, as many of the large structures of the Government are undergoing their first severe test.

The Colorado River at Yuma, Ariz., is discharging 150,000 sec.-ft. Both the Laguna dam and the levee system are standing the strain extremely well and it is believed they could successfully resist a flood several feet higher than the one now passing, although it is the highest known on that river.

The North Platte River in Wyoming has been carrying more than twice the volume of water ever recorded there before, and many alarming stories have been circulated concerning the safety of the Pathfinder dam recently completed by the Reclamation Service. Some apprehension was felt owing to the long-continued high water lest it should top a low point in the reservoir south of the dam. However, a dike was thrown across the opening, and as the river is slowly falling the danger is now past. The total flow of the river for the past 45 days has exceeded the normal yearly flow of the river at that point.

The Lower Yellowstone, Shoshone, Salt River and other streams in which dams are under construction, have all carried floods of unheard of volume, but so far no serious damage has been caused. In other sections the rivers and canals are bank-full and the outlook for heavy crops throughout the West is very bright.

ADDITIONS TO THE U. S. RECLAMATION SERVICE funds during the year ended on June 30, 1906, totalled about $7,770,000. In addition, there has accrued to the credit of the fund about $1,000,000, paid or payable by farmers under the various irrigation works which are already supplying water.

THE HETCH-HETCHY WATER PROJECT for a municipal water-supply for San Francisco can now proceed in its preliminary stages, the court injunction against issuing bonds having been dissolved and $240,000 of bonds having been sold.

Personals.

Mr. M. D. Schaff, Superintendent of the Chicago, Peoria & St. Louis Ry., has been made General Superintendent, and the position of superintendent has been abolished.

Mr. A. M. Van Auken has been appointed Resident Engineer of the Jonesboro, Lake City & Eastern R. R., at Blytheville, Ark., in charge of the maintenance of track, bridges and buildings.

Mr. H. Almert, an engineer of long practice in Chicago, has been appointed Manager of the department of examinations and reports of H. M. Byllesby & Co., engineers, with headquarters at Chicago.

Mr. Jason R. Holman has been appointed Chief Engineer of the Oregon & Washington R. R., with headquarters at Seattle, Wash., to succeed Henry F. Baldwin, whose death was recorded in this column June 24.

Mr. W. R. Thompson, M. Am. Inst. E. E., recently Assistant Electrical Engineer of the New York Public Service Commission, has been appointed Assistant to the Chief Engineer of H. M. Byllesby & Co., with headquarters at Chicago.

Mr. C. F. Brown, Assoc. M. Am. Soc. C. E., formerly in charge of drainage investigations for the U. S. Department of Agriculture in Utah, Colorado, Wyoming, and Texas, has opened an office at 317 Boston Bldg., Salt Lake City, Utah.

Four members of the Panama Canal Committee of the New York Chamber of Commerce sailed for Colon from New York on July 12. Those taking the trip are Messrs. John R. Dunlap, Wm. L. Saunders, Cornelius A. Pugsley and Julio F. Sorzano.

Mr. Hugh M. Wilson, formerly Editor and publisher of the "Railway Age," will, on Aug. 1, become associated with the Barney & Smith Car Co., Dayton, Ohio, as a director and a Vice-President. Mr. Wilson disposed of his publishing business over a year ago and has only recently returned to the United States after nearly a year spent in foreign travel.

Mr. H. G. Nicholls, for several years Assistant General Manager of the Canadian General Electric Co. and the Canada Foundry Co., has resigned that position and has organized a company under the name of Factory Products Limited, which will act as Canadian selling agents for representative manufacturers. Mr. Nicholls' offices are in the Confederation Life Bldg., Toronto, Ont.

Mr. R. B. Ketchum, M. Am. Soc. C. E., at present Chief Engineer of the Kansas-Colorado R. R. Co. and the Kansas-Colorado Electric Transmission Co., has been appointed Associate Professor of Civil Engineering in the University of Utah. Mr. Ketchum was graduated from the University of Illinois with the degree of Bachelor of Science in civil engineering in 1896, and was given the advanced degree of Civil Engineer by the same institution in 1900. He has practiced since that time largely in the states of Colorado, Idaho, Montana and Utah. He was at different times Division Engineer of the Oregon Short Line R. R. and Chief Engineer of the Independent Coal & Coke Co.

Obituary.

Eben Ryder, General Superintendent of the Chicago, Indiana & Southern R. R., died July 7 in a sanatorium at Atlantic City, N. J., after an illness of more than a year. He was 56 years old.

Robert S. Brooks, M. Am. Inst. M. E., was drowned July 6 in the Yaqui River, Mexico. Mr. Brooks was a graduate of Princeton University in the class of 1898. At the time of his death he was in the employ of Dr. L. D. Ricketts, of Mexico City.

George H. French, Assoc. M. Am. Soc. C. E., U. S. Assistant Engineer with the Mississippi River Commission, died July 9 at his home in Maplewood, Mass. Mr. French was born at Milton, Ill., in 1860 and had worked with the Mississippi River Commission for the past 25 years.

Atilla Cox, President of the Louisville, Henderson & St. Louis Ry., died July 7 in Louisville, Ky., after an illness of several months. Mr. Cox was born in the village of Ghent, Ky., in 1843. He was made Receiver of the Louisville, Henderson & St. Louis Ry. in 1893 and became President of that railway during the same year.

John Morse Ordway, who was for 15 years Professor of Industrial Chemistry and Metallurgy at the Massachusetts Institute of Technology, died July 5 at Saugus, Mass. Mr. Ordway was born at Amesbury, Mass., in 1823, and received the degree of A. M. from Dartmouth College in 1844. Before joining the faculty of the Massachusetts Institute, he was superintendent and chemist at various times of many chemical industrial plants in New England. For 13 years after leaving the Massachusetts Institute of Technology he was a member of the faculty of Tulane University, from which he retired three years ago.

Elwyn G. Hovey, an electrical engineer, died at his residence in Upper Montclair, N. J., July 8, aged 42 years. Mr. Hovey was a graduate of Dartmouth College, class of 1888, and immediately after graduation entered the employ of the Western Electric Co., at Chicago, Ill. After serving in various capacities he specialized on the design and construction of telephone central exchanges and in 1897 was sent to Japan to supervise the construction of several large telephone exchanges. After he returned from this work, he was transferred to the New York City office of the same company and remained in their service up to the time of his death.

Livingston J. Little, a civil engineer, died June 25 at Rochester, N. Y. Mr. Little was a graduate of Union College in the class of 1886 and was later an instructor in civil engineering at that school. He afterward spent several years in Chile, South America, where he was employed on railway construction work. In 1901-2 he was in eastern Siberia assisting in the development of silver mines and, from 1904 to '08 he was in the service of the U. S. Government on construction work at Panama. While in Panama, he contracted tuberculosis, which eventually caused his death. For a short time previous to his last illness, Mr. Little was employed by the Chicago & Northwestern Ry., at Chicago, Ill.

Simon Newcomb, the eminent astronomer and mathematician, died July 11 at his home in Washington, D. C. Mr. Newcomb was born at Wallace, N. S., in 1835, and was educated by his father. He came to the United States in 1853, taught school in Maryland from 1854 to '56, and in 1857 worked as a computer on the Nautical Almanac. He was graduated at the Lawrence Scientific School of Harvard University in the class of 1858, and subsequently received at various times the degrees of LL. D., Sc. D., Doctor of Mathematics and Doctor of Natural Philosophy from prominent universities in this country and in Europe. In 1861 he was appointed Professor of mathematics in the U. S. Navy and was later assigned to duty at the U. S. Naval Observatory at Washington, D. C., where he negotiated the contract for and superintended the construction of the 26-in. equatorial telescope. In 1884 he became Professor of mathematics and astronomy at Johns Hopkins University and held that position for ten years. Mr. Newcomb was retired from the navy upon attaining the age of 62 years, in 1897, with the rank of Rear-Admiral. He was the author of a number of books on astronomy and of shorter papers setting forth the results of his astronomical researches.

Engineering Societies.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Aug. 9-14. Annual meeting at Spokane, Wash. Secy., B. A. Fowler, Phoenix, Ariz.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 25-27. Annual convention at Montreal, Can. Secy., John MacVicar, Des Moines, Iowa.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Aug. 31-Sept. 2. Annual meeting at Briarcliff Manor, N. Y. Secy., D. L. Huntington, Spokane, Wash.

TRAVELING ENGINEERS' ASSOCIATION.
Sept. 7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 8-10. Annual convention at New York City. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 14-16. Annual convention at Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 14-17. Annual meeting on board steamer sailing from Detroit, Mich. Secy., A. P. Ewing, Gas Office Bldg., Detroit, Mich.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Sept. 16-Oct. 12. Annual convention and excursion on special train starting at Chicago, Ill. Secy., R. W. Raymond, 29 W. 39th St., New York City.